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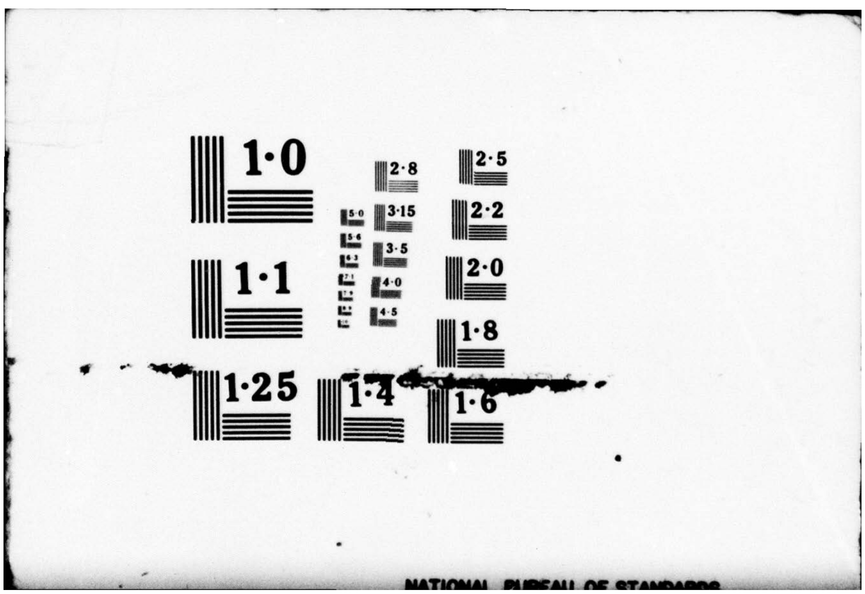
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Technical Report NAVTRAEQUIPCEN 75-C-0095-1

GENERALIZED SONAR OPERATOR TRAINING: FUNCTIONAL SPECIFICATION AND EVALUATION PLAN

Honeywell
Minneapolis, Minnesota 55413

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The objectives of this program were to develop the functional specifications and an evaluation plan for a Generalized Sonar Operator Training (GenSOT) system. A previous study had established GenSOT feasibility based upon similarities among the tasks, skill, and knowledge required to operate a variety of surface and subsurface sonar systems. The current program focused upon implementation feasibility.

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The development of GenSOT was considered because a more cost-effective solution for sonar operator training was needed. A training system was specified which is postulated to have the following advantages:

- Increased sonar operator proficiency per unit of training time and cost.
- Decreased time required for skill transfer from one sonar system to another.
- Increased sonar operator understanding of the basic functions of sonar equipment to ensure optimal equipment operation.

In addition, the following plans were prepared to evaluate the concept under operational conditions:

- A plan for the introduction of GenSOT into the overall sonar operator training sequence.
- A plan for measuring the cost of GenSOT and comparing those costs to current costs.
- An experimental design for comparing the effectiveness of GenSOT with current sonar operator training.

FOREWORD

This is the second report of Project 4753, "The Feasibility of Generalized Acoustic Sensor Operator Training." The report provides the functional specifications and an evaluation plan for an experimental Generalized Sonar Operator Training (GENSOT) system. Work on this project has been discontinued due to reduced funding.

The work was supported by the Naval Sea Systems Command Technology Office, NAVSEA 06H1-3. Acknowledgement is gratefully extended to Mr. James P. Jenkins and Mr. Curtis L. Martin for their contributions.

William P. Lane

WILLIAM P. LANE

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SECTION I

INTRODUCTION

This report covers the work done in the second phase of the program, "The Feasibility of Generalized Acoustic Sensor Operator Training," sponsored by the Naval Training Equipment Center under NAVTRAEQUIPCEN Contract No. N61339-75-C-0095.

The objectives of this Phase II were to develop functional specifications and an evaluation plan for a Generalized Sonar Operator Training (GenSOT) system. The accomplishment of these objectives builds upon and extends the findings of our previous effort in which the feasibility of a GenSOT approach was established from similarities among the tasks, skills, and knowledge required to operate a large sample of sonar systems. Phase II focused on the question of how to best implement a SenSOT system and related device.

Our approach was to determine the sonar system operating requirements for the mission phases in which common tasks occurred. This information was then used to define the training requirements associated with those operating requirements. Together, these requirements served as the basis for development of GenSOT system training objectives and preliminary system characteristics. Finally, a plan was developed to guide the experimental evaluation of the resulting GenSOT system.

The Phase I study of the feasibility of Generalized Sensor Operator Training (GenSOT) indicated that there was sufficient commonality in task, skill, and

knowledge requirements for sonar operators to warrant further investigation of GenSOT system implementation. While such commonality is necessary for generalized training, it is not a sufficient reason for changing the current sonar operator training program. The demonstration of commonality suggested that GenSOT could be accomplished; it did not show that GenSOT should be adopted. Phase II work was directed toward answering the following question: Should the Navy use generalized training for acoustic sensor operators (ASO's)

Our answer to this question takes the following form: If the training of sonar concepts and the relationships among the main elements of sonar equipment operation are more important than specific "knobology" training during the initial stages of operator training, and if course length can be shortened through training device simplicity, then generalized training will result in a better trained sonar operator at less cost than training using specific sonar equipment.

In this report, we present and support the reasoning which yielded this conclusion. In addition, and more importantly, we present detailed plans for converting our answer to a definite statement of the feasibility of GenSOT. Phase II does not deal with the development of engineering design specifications for a GenSOT device. Instead, we are concerned with the implication of GenSOT for training all Naval ASO's. This report deals with a definition of factors which relate to generalized training of ASO's. From these factors, detailed plans were developed to provide empirical data for the evaluation of the feasibility of a GenSOT approach. More succinctly, we have answered two questions:

- What is GenSOT?
- How should GenSOT be implemented?

ASO TRAINING PROBLEMS

From a very simplistic point of view we could state that, if ASO's complete training and are able to perform their job with the fleet, and if the cost and length of training are not excessive, then there are no training problems. Is this the case? The lack of proficiency standards and the lack of a measure of excessive cost and time make it impossible to provide such a simple answer.

However, suggestive data are available indicating that there are training problems. For example, cognizant people in the fleet have been known to make unfavorable comments about the quality of recently trained ASO's. An inspection of school course outlines, curricula, training aids, and operator's manuals shows great variability across different sonar systems in the thoroughness with which topics are covered during training. However, many sonar concepts and functional relationships are constant and not a function of the particular sonar system. Thus, these topics could be treated uniformly under the concept of generalized training.

Lack of uniformity is also suggested by comparing course cost and course length for different sonar system training. An example is that the total cost per student for the SQQ-23 operator course is $2,600 ($382 per week) for a 6.8 week course while the cost per student for the BQQ-5 operator course is $18,900 for a 27.9 week course (or an average cost of $677).

Further the average cost per week for a student in the SQS-35 operator course is $2,116. These considerations suggest that proficiency levels for ASO graduates are likely to be different.

There are many conclusions which could be reached, ranging from an assumption that all ASO's are fully proficient but some courses cost too much, to some ASO courses do not provide adequately proficient ASO's due to course cost or length or both. These conclusions represent extremes, and we suspect that the correct conclusion lies in the middle ground. The main point for GenSOT feasibility is that there are unevenesses in ASO courses which probably impact the proficiency level of the trainees as well as the cost of training.

Operating on the assumption that there is a definable set of basic skill and knowledge required by all sonar operators, one could question the reasons for these rather large differences in training time and costs. One method of making A School training more efficient would be to standardize and, perhaps, shorten its length unsing the GenSOT approach. This course appears especially attractive in light of the apparent upward trend in training costs for operators of "new generation" sonar systems.

Given this strong motivation for considering generalized ASO training, we have determined the functional requirements for a GenSOT device, and we have prepared plans for measuring the cost and effectiveness of generalized versus specific ASO training.

BACKGROUND

Before introducing the Phase II accomplishments, it is helpful to review the results and conclusions from Phase I (Daniels and Alden, 1975).[1] The approach consists of analyzing a representative sample of surface and subsurface sonar and acoustic warfare equipment to identify the training areas and operator performance requirements which could be supported by a generalized training approach. Behavioral task statements of operator functions for 14 sonar systems were derived from sonar system specifications and operator task inventories. These statements were taxonomically coded and categorized by system platform, system type, primary tactical mission, and behavioral function in order to provide the data base for commonality analysis.

Results were examined from two reference points. First, the feasibility of a general sonar operator training approach in terms of degree of commonality in operator task, skill, and knowledge requirements was studied. Second, the feasibility of generalized training was addressed on the basis of available training and hardware simulation technologies for providing the stimulus and response capabilities necessary to train the common operator tasks, skills, and knowledge associated with sonar and acoustic warfare systems.

Findings indicated a high degree of commonality in operator tasks characterized by stimuli of low to moderate uncertainty, procedure following, and simple motor responses. Descriptively, the common job elements for the sonar operator consist of activating a push-button or rotary switch in

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[1] Daniels, R. W. and Alden, D. G., "The Feasibility of Generalized Acoustic Sensor Operator Training," NAVTRAEQUIPCEN 74-C-0067-1, 1975.

accordance with a specific rule or procedure when a familiar signal light appears. This commonality was found principally in the setup/turn-on, search/detect, and track phases of the tactical mission. Thus, the training of operators for current and future surface and subsurface sonar systems should primarily emphasize the skills and knowledge associated with the capability to set up and configure the system to maximize the acoustic information presentation. Observed from the findings was the trend that the sonar system optimization function is becoming more of a team task with direction from the sonar supervisor.

The conclusions reached from the first year's work were the following:

- Generalized Acoustic Sensor Operating Training is feasible based on commonality of tasks performed by ASO's.
- The nature of common tasks indicates the emphasis of GenSOT should be upon equipment operation and procedure following skills.
- Training of those skills should focus on equipment setup, search/detect, and track mission phase requirements.
- The unique tasks, skills, and knowledge required for signal interpretation and classification activities are <u>not</u> appropriate for inclusion in a GenSOT program.
- GenSOT should involve an operator console simulation.
- A high degree of display fidelity is <u>not</u> required.

APPROACH SUMMARY

Our Phase II approach covers four areas:

I. A definition of ASO training objectives in measurable terms.

II. An examination of the current methods for meeting these objectives.

III. A derivation of improved methods for meeting training objectives.

IV. The development of plans for evaluating the new methods.

Figure 1 shows an expansion of the study approach areas A through D covered during Phase II. Some of the topics shown in Area A were covered in the first phase of work. An overview of the multiphase program, shown in Figure 2, is included to place the current phase in perspective.

For our overall program approach (Figure 2), it was decided that all the questions should be answered and uncertainties reduced before investing in the design and fabrication of a prototype GenSOT device. With this strategy in mind, we have, as part of the current phase, developed plans for determining the cost and effectiveness of generalized ASO training and for comparing generalized with specific training cost and effectiveness.

In summary, the program objectives stated earlier in this section were met. A functional description of a GenSOT device was derived from analyses of relevant data. The purpose of the GenSOT approach in ASO training was described and methods for evaluating the cost-effectiveness of that approach were developed.

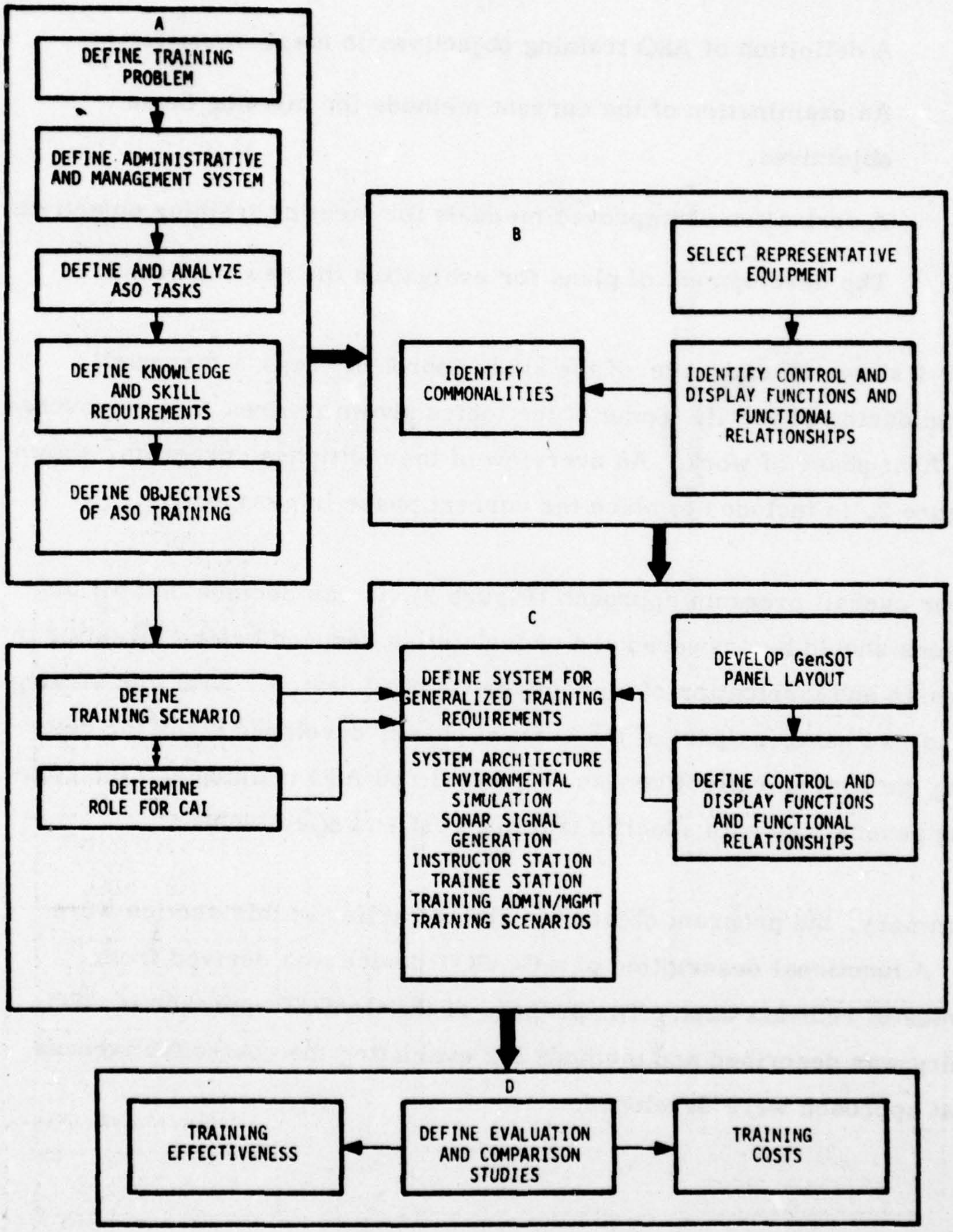

Figure 1. Study Approach

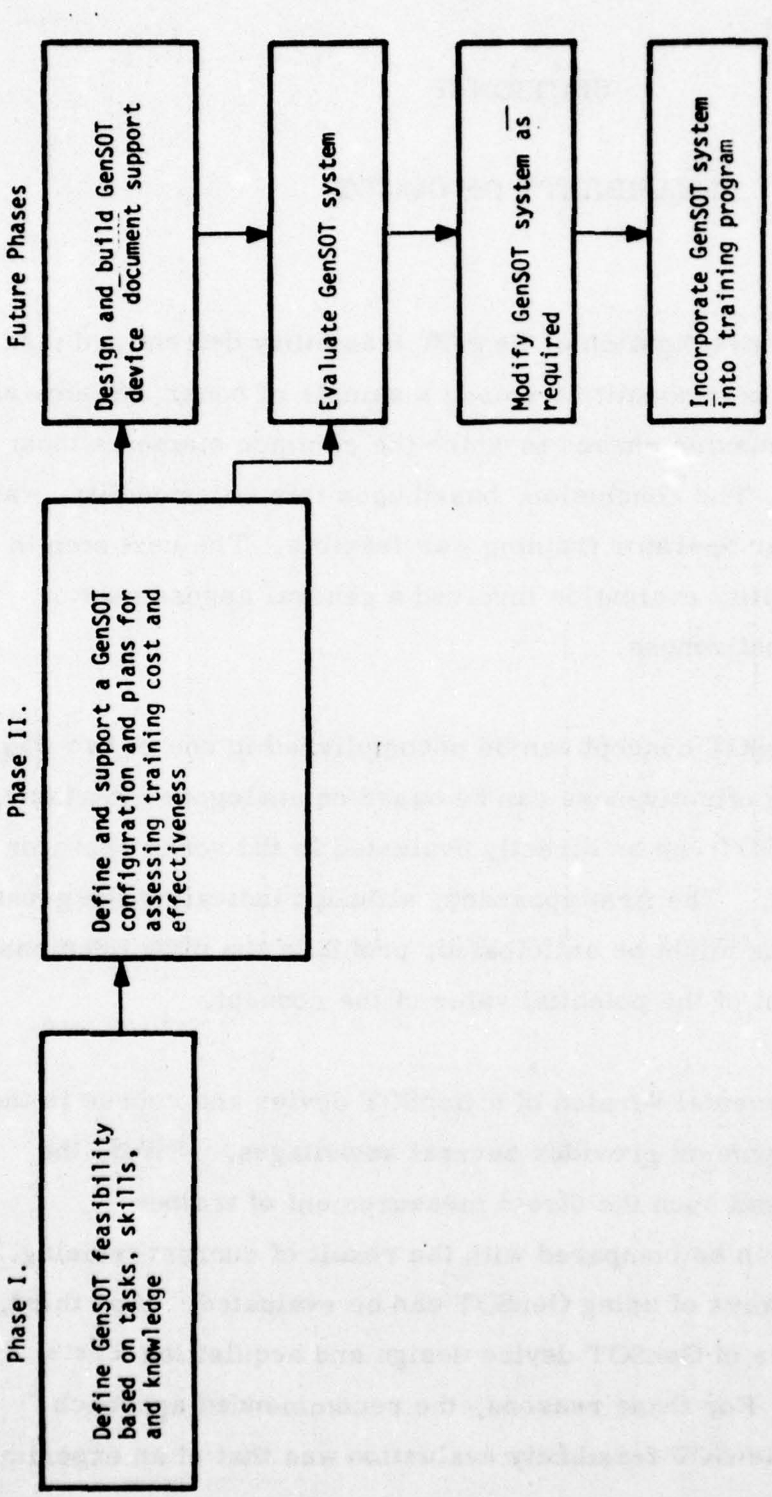

Figure 2. Program Approach

SECTION II

FEASIBILITY OF GenSOT

Honeywell's Phase I investigation of GenSOT feasibility determined task, skill, and knowledge commonalities among a sample of sonar systems and defined the tactical mission phases in which the common elements most frequently occurred. The conclusion, based upon this commonality, was that generalized sonar operator training was feasible. The next step in the process of feasibility evaluation involved a general assessment of training cost and effectiveness.

Evaluation of the GenSOT concept can be accomplished in one of two ways. Estimates of training effectiveness can be based on analogous situations, or the impact of GenSOT can be directly evaluated in the sonar operator training environment. The first approach, although indicating the general level of success which might be anticipated, prohibits the direct demonstration and measurement of the potential value of the concept.

Evaluating an experimental version of a GenSOT device and course in the actual training environment provides several advantages. First, the evaluation can be based upon the direct measurement of trainee performance which can be compared with the result of current training. Second, alternative ways of using GenSOT can be evaluated. And third, a more valid estimate of GenSOT device design and acquisition costs can be established. For these reasons, the recommended approach for the next step in GenSOT feasibility evaluation was that of an experimental

evaluation of the concept. To conduct that evaluation, it was necessary to specify what, who, how, and where to train. From the Phase I study, the following conclusions were drawn:

- What should be trained?
  - General functional nomenclature
  - Operational procedures for system setup, search, and manual and automatic tracking
  - Control and display functions and all interrelationships
  - Display interpretation with variable stimulus uncertainty
- Who should be trained?
  - Anyone expected to operate a sonar system
- Where should training be provided?
  - During A School or its equivalent
- How should training be accomplished?
  - Classroom instruction plus a simulation of controls, displays, and functions

Because definition of the characteristics of an experimental facility for evaluating GenSOT is dependent on the purpose of the device, a set of assumptions was developed to guide the definition process. Those assumptions are:

1. The GenSOT device will support the objectives of training developed during this program.
2. Emphasis of GenSOT will be on learning sonar system characteristics and functions rather than on mere operation of the GenSOT device or a specific sonar system.

3. The evaluation of GenSOT will be done in the A School environment.

4. The recommended GenSOT device evaluation will permit measurement of trainee performance but will not be adequate for a complete evaluation of all aspects of ASO training.

5. The GenSOT device will be a prototype and not an engineering model of an operational GenSOT system.

DEFINITION OF GenSOT SYSTEM TRAINING OBJECTIVES

The definition of GenSOT system characteristics was based on identification of sonar system and operator task commonalities and on GenSOT objectives. The definition of those training objectives required consideration of the potential impact of GenSOT device design on subsequent sonar operator training--namely, the possibility of negative transfer from practice on a GenSOT device to subsequent training on an actual sonar system. A specific concern was that overlearning in the areas of display and control placement and procedural steps represented in a GenSOT device might negatively affect subsequent learning of an operational sonar. To combat this potential problem, an approach was taken which was designed to actively discourage trainees from overlearning the specific operational characteristics of the GenSOT device. Based upon the previously stated assumptions, GenSOT objectives were for elements of the job which were commonly required across most of the sonar systems in our sample.

Mackie, McCauley, and Ridihalgh (1975),[2] in investigating criteria for the selection and evaluation of sonar technicians, developed and reported information relevant to GenSOT objectives. Specifically, they analyzed 11 sonars and identified the general knowledge requirements, sonar display formats, common perceptual and cognitive requirements, common controls and control functions, and common motor skill requirements for essentially the same sample of sonars used for this study. Because of the currency and appropriateness of the information reported by Mackie et. al., those data were used to assist in the development of GenSOT objectives. The data were analyzed to determine those common elements which were representative of the greatest number of sonar systems. That information was then compared with the findings of our Phase I study. This comparison showed, first, the identification and verification of common operator requirements and, second, a preliminary selection of those requirements appropriate for GenSOT objectives. Although presented in different formats, the data from the two efforts were highly similar.

The subsequent comparison of these common elements with the ST A School curriculum identified those requirements which were most appropriately supported by GenSOT. A guideline established for this purpose was to generally assign knowledge acquisition training to a lecture or classroom, and knowledge use (skill training) to a GenSOT device.

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[2]Mackie, R. R., McCauley, M. E., and Ridihalgh, R. R., "Research on new criteria for the selection and evaluation of sonar technicians: Phase 1 (U)," Report No. NPRDC TR 75-24, Navy Personnel Research and Development Center, San Diego, California, 1975. Confidential.

Furthermore, based upon the findings of our previous study, contact classification training and fire control operation were eliminated from the GenSOT system. This exclusion reflected our finding that the tasks, skills, and knowledge for the classification phase of sonar operation were not sufficiently common to warrant including that capability in a GenSOT course. It should be noted, however, that the skill required to properly manipulate sonar system controls and displays and the functions and interrelationships to optimize the sonar configuration for the classification process are similar to those for the search and track phases. Therefore, the basic system skill elements required for classification would still be covered by GenSOT.

Two sets of objectives were developed for GenSOT. The first set related to the general objectives for the development of a GenSOT system. These objectives require that the experimental training system have the following features:

- Representation of basic sonar functions,
- Controls requiring exercise of basic sonar operator skills,
- Displays for the representation of typical classes of sonar information formats,
- Consideration of a multistation layout for simultaneous training of sonar students,
- A computer based system,
- To provide a plan for the introduction of GenSOT into the overall sonar operator training sequence,
- To provide a plan for comparing the cost and effectiveness of GenSOT with current sonar operator training.

The second set represents the training objectives for GenSOT. These objectives reflect the basic parameters upon which the training effectiveness of the experimental GenSOT system should be evaluated. Further, these objectives dictate the simulation characteristics of that system. These GenSOT training objectives are the following:

- To increase sonar operator's proficiency per unit of training time and cost.
- To increase the sonar operator's understanding of the basic functions of sonar equipment to ensure optimal equipment operation.
- To decrease the time required for positive training transfer from one sonar system to another.

Table 1 presents the behavioral objectives for a GenSOT system. These objectives were developed from a number of information sources including the ST A School curricula, requirements for advancement in rating, the work of Parker and Greene,[3] and that of Mackie, et al.[4]

PERFORMANCE MEASUREMENT

Measures of trainee performance were derived directly from the GenSOT system behavioral objectives. The specific measurements to be taken were dictated

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[3]Parker, E.L., and Greene, C.R., "Evaluation Criteria-Initial Sonar Operator Training (U)," Final Report to Naval Ship Systems Command, Contract NOOO 24-71-C-1030, 1972.

[4]Mackie, et al., *op cit.*

TABLE 1. GenSOT SYSTEM BEHAVIORAL OBJECTIVES

Name and describe

- Controls and functions
- Displays, functions, and formats
- Control interrelationships
- Control/display interrelationships
- Major operating modes
- Procedures

Configure and operate a GenSOT device for

- Turn on/energize/initialize
- Mode select
- Active and passive search
- Track, active and passive, manual and automatic
- Degraded operation and PM/FL
- Classification configuration
- Procedure following
    - Contact report
    - No echoes
    - Lost contact report and procedure
    - Regain contact
    - Multiple echo/target
    - Attack

both by the objectives of GenSOT and the objectives of this phase of the program.

The overall objective of a GenSOT system is to prepare a trainee for subsequent training and ultimately his job at sea. Success or failure in meeting this objective is determined by measures which identify how well trainees learn the skills trained in a GenSOT system and how well those skills transfer. Consequently, there is a need to assess trainee performance before, during, and following exposure to GenSOT. Measurement before GenSOT establishes the input skill level of trainees. Measurement during and after GenSOT provides an index of progress in grasping generalized concepts, and measurement after training on a specific sonar system provides the final metric for evaluating the efficiency and effectiveness of GenSOT.

To support the GenSOT evaluation experiments, behavioral data are needed which indicate the progression of skill acquisition as a function of training and practice. Because the focus of GenSOT application is at the initial stages of training, the emphasis of that training should be upon building a basic understanding of and facility for accomplishing equipment operating procedures. Consequently, measures of accuracy appear to be the most meaningful for the measurement of basic understanding while speed of response is appropriate for the measurement of facility. Later in the training cycle, when the requirement for team interaction is taught, measures of speed, pacing, and coordination become more important. However, even in those latter stages, the requirement for performance accuracy is assumed to be predominant.

Although it is normal to establish an arbitrary criterion (e.g., 90 percent correct on a test) for whether the objectives of training are adequately met, this seems of limited value for the current situation. More importantly, there is a need to determine the level of proficiency attained for GenSOT as compared to conventional training. Again, that determination is required both during and following GenSOT.

SECTION III

GenSOT DEVICE FUNCTIONS, OPERATING MODES, AND FUNCTIONAL RELATIONSHIPS

COMMON MODES AND FUNCTIONS

Defining characteristics of a training device to support GenSOT was a four step process: (1) common sonar system functions were identified; (2) operating modes associated with the search and track mission phases were defined; (3) system configurations used during the various operating modes were determined; and (4) specific controls, displays, and interrelationships needed for training the various functions and modes were specified.

These steps were based on existing data and data developed during this study. Existing data were available from our previous GenSOT study, the Parker and Greene[4] report, and the Mackie[5] report. Each of those sources discussed the representativeness, characteristics, and expected longevity of various sonar systems. Selection of a sample of sonar systems for the current study was based upon a review of that information and on discussions with Naval and industrial personnel. Final selection of the sample for this effort was based on the above system criteria, the existence of a shore-based training course for the system under consideration, and availability of descriptive documentation for the sonar systems.

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[4] Parker and Greene, op. cit.

[5] Mackie et al., op. cit.

The resulting sample was composed of the following:

AN/SQS-4	AN/BQS-4
AN/SQS-26(CX)	AN/BQR-21
AN/SQS-35(V)/38	AN/BQR-20A
AN/SQQ-23 PAIR	AN/BQQ-5(BQS-13)

This sample became the focus and source of all sonar system data for the current effort.

The system functions associated with each sonar in the sample were identified. On that basis sonars were combined for further analysis according to the plan shown in Figure 3. In this manner a progressively more general statement of sonar system functions was defined until finally the common features for systems in the sample were identified.

Common functions were defined as those which occurred in at least five systems in the sample while unique functions were those found in only one or two of the systems. The resulting common functions were compared with data from the Parker and Greene[6] and the Mackie[7] reports. That comparison revealed, even with somewhat different samples of sonars, close agreement on common system functions. The system functions, together with their relevant parameters, selected for inclusion in a GenSOT device are presented in Table 2. The first basis for function and parameter selection was representativeness of the function across sonar systems. Second, functions were selected which had a direct relationship to the common operator requirements for various mission phases identified in our earlier study. (Those specific mission phases were equipment setup, search, and track.)

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[6] Parker and Greene, op. cit.

[7] Mackie et al., op. cit.

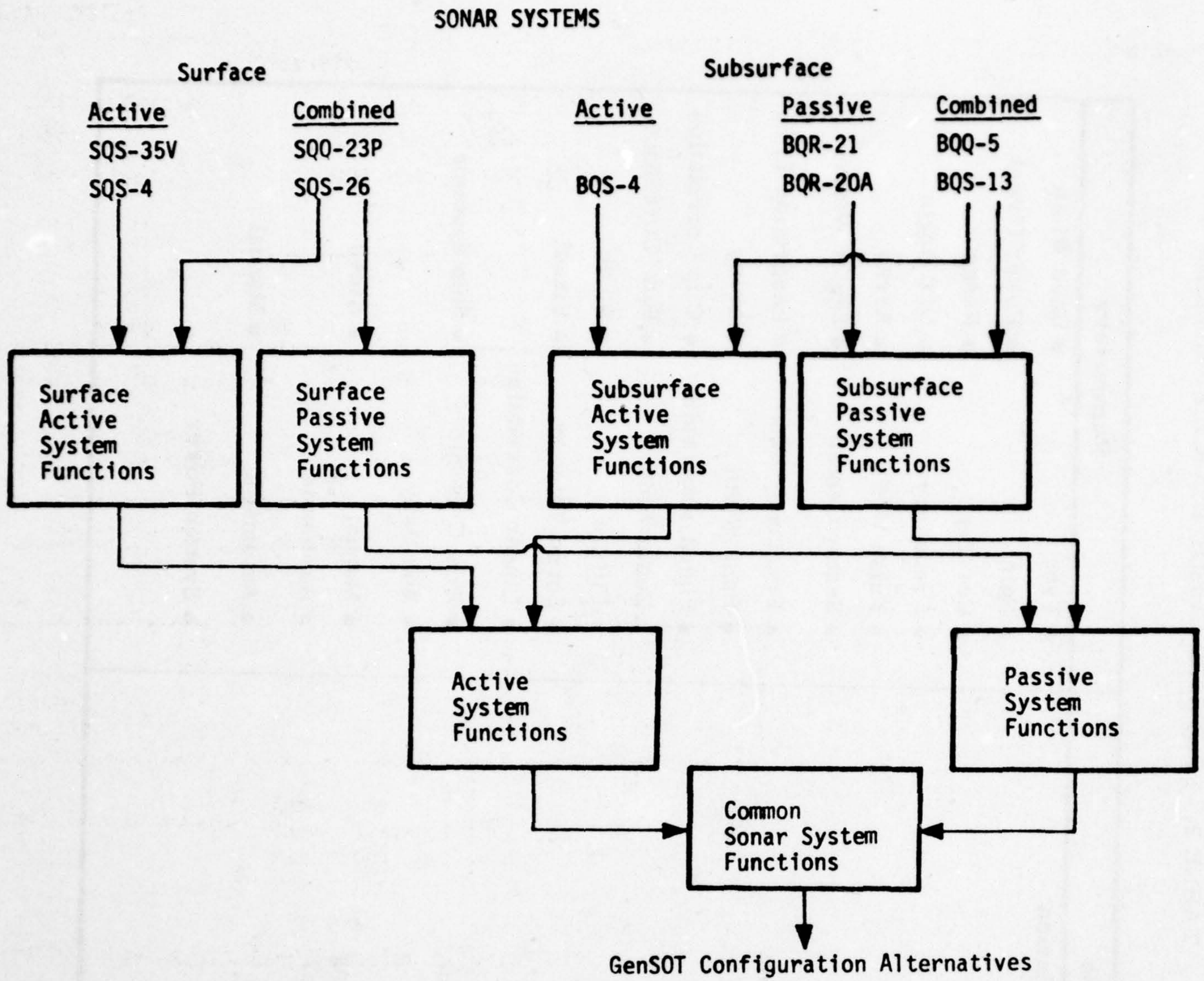

Figure 3. GenSOT Device Characteristics Derivation from Characteristics and Functions of Selected Sonar Sets

TABLE 2. PROPOSED GenSOT DEVICE FUNCTIONS

Functions	Parameters	
Transmission	• Type	• Band Width
	• Path	• Power Output
	• Coverage	• Range
	• Frequency	• D/E Angle
	• Pulse Width	• Array
	• Sector Center	• Sector Width
Reception	• Frequency Band	• Integration Time
	• Band Width	• Array
	• Signal Processing	• Clip Correlation
	• Beam Width	• Sum/Difference
	• Filters	• Audio
	• Sound Velocity	• Visual
	• Linear Correlation	
Interface	• Fire Control	• Ship Systems
	• Auxillary	
Tracking	• Manual	• Aided
	• Automatic	
PM/FL	• Automatic	• Manual
Other	• System Power	

Additionally, because GenSOT is intended to meet the training requirements of operators for all sonar systems, the device supporting such training requirements must allow both active and passive mode configurations. Finally, both the normal and degraded system capabilities were needed to permit training operators in the use of their systems when some degraded system performance characteristics existed.

These considerations led to the selection of eight major operating modes for inclusion in a GenSOT device: normal and degraded modes for active and passive, search and track.

Due to the common requirement for sonar operators to constantly interact with other systems and areas aboard their ships, the capability to interface with other systems was also selected for inclusion in the GenSOT device.

Although not an operating mode, the need to interact with other ship systems (e.g., gyro) and areas (e.g., fire control) does have implications for the specific controls, displays, and interactions included in a GenSOT device. For that reason system interaction has been included as a GenSOT device requirement.

For each operating mode specified above, the common system configurations to be represented are as follows:

<u>Active Search</u>

- Surface Duct
- Bottom Bounce
- Convergence Zone
- Direct Path
- Audio

<u>Passive Search</u>

- Visual
- Audio

Active Track
- Manual
- Aided
- Automatic

Passive Track
- Manual
- Aided
- Automatic

Interact
- Manual
- Automatic

Selection of the GenSOT device mode configurations was based upon the commonality of those configuration options in the sample of sonars analyzed. The definition of commonality for modes was based on the relative frequency and importance of various modes in the general training of novice sonar operators. This judgmental process was weighted by the configurations of five sonars in the sample. Specifically, because of their current and projected status, GenSOT device configuration options were weighted more heavily for:

- AN/SQS-26
- AN/SQS-35(V)/38
- AN/SQQ-23 PAIR
- AN/BQR-21
- AN/BQQ-5

That weighting resulted in the definition of GenSOT device configuration characteristics which are more representative of the "standard" systems of the "1980" inventory. Such weighting is very appropriate in light of the stated GenSOT objectives.

AIRBORNE ASO TRAINING

The AQA-7 airborne sonar system has knowledge, skill, functional, and procedural commonalities with surface and subsurface sonar systems. However, the plans for the introduction of Proteus make this finding obsolete. During the course of the GenSOT data collection task, the design for Proteus and thus the specific training requirements were not fixed. Design changes to Proteus were occurring on a monthly and sometimes weekly basis, and the documentation naturally lagged the actual design modifications. For this reason the applicability of GenSOT for airborne ASO training was not included in this study.

CONTROL AND DISPLAY REQUIREMENTS

The final step in defining a GenSOT device configuration was selection of the specific controls, displays, and interrelationships. Two options were available to guide this process. First, we might have selected exact replicas of controls and displays found on operational sonars. That option was rejected in favor of a second which was to choose a sample of control and display types which is generally found on operational systems. Assignment of specific control and display types to the various functional parameters, however, was based upon convenience. If, for instance, a functional parameter seemed most appropriately controlled by a multiposition rotary switch, that control type was selected as an option. Similarly, there were many cases where the type of function to be performed could be controlled equally well by more than one approach. In these cases each of the alternatives was listed. Similarly, in the case of displays, the specific hardware used to display information was considered less important than

the accurate representation of the information presented. Consequently, the experimental versions of a GenSOT device have been configured with several types of controls and displays.

Table 3 presents the controls selected for use in implementing GenSOT functions and parameters with the number of levels recommended for each parameter. Interactions between various functions and parameters have been preliminarily defined and are included in Appendix A.

Table 4 presents the displays recommended for inclusion in a GenSOT device. Selection of display types was based upon the relationship of displays and controls normally encountered in operational sonars.

The requirement for both CRT and paper chart displays reflects the need to train for both passive and active signals and the requirement to train the simultaneous monitoring of multiple data displays.

TABLE 3. REPRESENTATIVE CONTROLS FOR A GenSOT DEVICE

FUNCTION	PARAMETER	CONTROL TYPES	CONTROL POSITIONS
1. Transmission	1. Coverage	B, C, E	1. ODT 2. RDT 3. BB+RDT OMNI 4. CZ+RDT OMNI
	2. Frequency	B, C, E	5. 3.0 kHz 6. 4.5 kHz 7. 6.0 kHz
	3. Pulse Width	B, C, E	8. 5 msec 9. 30 msec 10. 120 msec
	4. Band Width	B, C, E	11. 0.2 12. 6.0 13. 25.0
	5. Power Output	B, C, E	14. Off 15. 120 dB 16. 130 dB 17. 140 dB
	6. Type	A, B, E	18. CW 19. FM

CONTROL TYPES

A. Toggle switches
B. Push-button switches
C. Multiposition rotary switches
D. Continuous rotary
E. Keyboard
F. Stiff stick
G. Joystick
H. Track ball
I. Handwheel

TABLE 3. REPRESENTATIVE CONTROLS FOR A GenSOT DEVICE (Continued)

FUNCTION	PARAMETER	CONTROL TYPES	CONTROL POSITIONS
	7. Path	B, C, E	20. Surface Duct 21. Bottom Bounce 22. Convergence Zone 23. Direct
	8. Range	B, C, E	24. 1 kyd 25. 5 kyd 26. 25 kyd 27. 50 kyd 28. 100 kyd
	9. Array	A, B, E	29. Spherical 30. Cylindrical
	10. D/E Angle	D, E	31. $+10^{\circ}$ to -40° (in 1° steps)
	11. Sector Center	D, E	32. 0° to 360° (in 1° steps)
	12. Sector Width	B, C, E	33. 30° 34. 70° 35. 100° 36. 150° 37. 200°
2. Reception	1. Frequency Band	A, B, C, E	38. 0-100 Hz 39. 100 Hz to 1 kHz 40. 1 kHz to 2 kHz
	2. Band Width	B, C, E	41. 1000 Hz 42. 2000 Hz 43. 3000 Hz 44. 4000 Hz 45. 5000 Hz
	3. Signal Processing	A, B, E	46. Off 47. Hetrodyne

TABLE 3. REPRESENTATIVE CONTROLS FOR A GenSOT DEVICE (Continued)

FUNCTION	PARAMETER	CONTROL TYPES	CONTROL POSITIONS
	4. Beam Width (Preformed Beam)	B, C, E	48. 5^o 49. 10^o 50. 15^o
	5. Array	B, C, E	51. Spherical 52. Cylindrical 53. Linear
	6. Integration Time	B, C, E	54. Off 55. STA 56. ITA 57. LTA
	7. Integration Time	C, D, E	58. Off through 10 minutes (in 10-second steps)
	8. Band Pass Filters	B, C, E	59. Off 60. 0-500 cps 61. 0-2 kcps 62. 0-5 kcps 63. 0-10 kcps
	9. Sound Velocity	C, D, E	64. 4800 to 5000 fps (in 10 fps steps)
	10. Clip Correlation	A, B, E	65. On 66. Off
	11. Linear Correlation	A, B, E	67. On 68. Off
	12. Audio		
	A. Type	A, B, E	69. Analog 70. Digital
	B. Output	A, B, E	71. Phones 72. Speaker

TABLE 3. REPRESENTATIVE CONTROLS FOR A GenSOT DEVICE (Continued)

FUNCTION	PARAMETER	CONTROL TYPES	CONTROL POSITIONS
	C. Mode		
	1) Listen	A, B, E	73. On 74. Off
	2) Sum Difference	A, B, E	75. Sum 76. Difference
	3) Preformed Beam	A, B, E	77. On 78. Off
	4) Classi-fication	A, B, E	79. On 80. Off
	D. Audio Gain	D	81. Off to High
	E. AGC	A, B, E	82. On 83. Off
	F. Time Varied Gain	A, B, E	84. On 85. Off
	13. Visual Display, CRT		
	A. Format	B, C, E	86. A-Scan 87. B-Scan 88. PPI 89. Spectral 90. BTR 91. SSI 92. Doppler
	B. Display Center	A, B, C, E	93. TCD-On 94. TCD-Off 95. SCD-On 96. SCD-Off
	C. Display Controls	D	97. Focus 98. Intensity 99. Contrast 100. Cursor Intensity

TABLE 3. REPRESENTATIVE CONTROLS FOR A GenSOT DEVICE (Continued)

FUNCTION	PARAMETER	CONTROL TYPES	CONTROL POSITIONS
	14. Visual Display, Chart		
	A. Illumination	D	101. Off to High
	B. Anti-Saturation	B, C, E	102. Off 103. 1 104. 2 105. 3 106. 4
	C. Contrast	C, D	107. Off to High
	D. Threshold	C, D	108. Off to High
	E. Marking Density	C, D	109. Off to High
	F. Cursor	A, B	110. Mark 111. Off
	G. TBR/GRR	A, B, E	112. TBR 113. GRR
	H. Standby/On	A, B, E	114. STBY 115. On
	I. TBR Center	A, B, E	116. 000° 117. 180°
	J. GRR Update	A, B, E	118. Update 119. Center
	K. Target Range Rate	A, B, E	120. Off 121. Target Range Rate
	L. Total Range Rate	A, B, E	122. Off 123. Total Range Rate
	M. Gate	B, C, E	124. Off through 20 kyds

TABLE 3. REPRESENTATIVE CONTROLS FOR A GenSOT DEVICE (Continued)

FUNCTION	PARAMETER	CONTROL TYPES	CONTROL POSITIONS
3. Interfaces	1. Fire Control		
	A. ATF	A, B, E	125. Off 126. ATF
	B. Range Mark	A, B	127. Off 128. Mark
	C. Bearing Mark	A, B	129. Off 130. Mark
	D. On Target	A, B	131. Off 132. On Target
	E. Search	A, B	133. Off 134. Search
	2. Ship Systems		
	A. Own Ship Speed	C, D, E	135. 0 to 100 kts
	3. Auxillary		
	A. Tape Recorder	A, B, E	136. On 137. Off
4. Tracking	1. Manual		
	A. Bearing	D, F, G, H, I	138. 0^o-360^o
	B. Range	D, F, G, H, I	139. 0 to 100 kyds
	2. Aided		
	A. ATF	A, B, E	140. Off 141. ATF
	B. MTB	A, B, E	142. Off 143. MTB
	C. GTT	A, B, E	144. Off 145. GTT

TABLE 3. REPRESENTATIVE CONTROLS FOR A GenSOT DEVICE (Concluded)

FUNCTION	PARAMETER	CONTROL TYPES	CONTROL POSITIONS
	D. MCC	A, B, E	146. Off 147. MCC
	3. Automatic		
	A. Autotracker Select	A, B, E	148. Off 149. Auto
	B. Autotracker Number	B, C, E	150. 1 151. 2 152. 3 153. 4
	C. Autotracker Engage	A, B, E	154. Engage 155. Disengage
5. PM/FL	1. Master Test	A, B, E	156. Off 157. Test
	2. Subsystem Test	A, B, E	158. Off 159. Test
	3. Fail Reset	A, B, E	160. Off 161. Reset
6. Other	1. System Power	A, B, E	162. Off 163. On

TABLE 4. RECOMMENDED DISPLAYS FOR A GenSOT DEVICE

Function	Parameter	Display Type	Information Displayed
Transmission	Power Output	Meter	Transmit Power
Reception	Audio	Headphones	Audio Data
		Speaker	Audio Data
		Meter	S/N Ratio
	Visual, CRT	Raster Scan	Data
		CRT	Data
	Visual, Paper Chart	Paper Chart	Data
		Indicator	Paper Replace
		Indicator	Display Center (N-S)
	BDI	Meter	Bearing Deviation
Interface	ATF	Indicator	ATF available
	Power	Indicators	Power on/off
	Gyro	Indicator	Gyro on
Tracking (Search)	Bearing	Three-digit numerical own ship's dial	Transmit/receive direction
			Receiver direction
		Five-digit numerical	CRT cursor length
		SSI	Sector scanned
	ATF	Indicator	ATF available from fire control
PM/FL	Failure	Numerical	Keyboard entry repeater
Other	Power	Indicator	Power on

OPERATING PROCEDURES

The operating procedures developed for use with the GenSOT device are the vehicle for meeting the objectives of GenSOT. These procedures are needed for operating the system in each configuration and mode being taught. Required procedures are as follows:

A. System Set Up, Turn On, Initialize

B. Active Search (Normal and Degraded System Operation)

1. ODT, Surface Duct
2. ODT, Bottom Bounce
3. ODT, Convergence Zone
4. ODT, Direct
5. RDT, Surface Duct
6. RDT, Bottom Bounce
7. RDT, Convergence Zone
8. RDT, Direct
9. BB + RDT, OMNI
10. CZ + RDT, OMNI

C. Passive Search (Normal and Degraded System Operation)

1. Visual
2. Aural

D. Active Track (Normal and Degraded System Operation)

1. Manual (MTB, MCC)
2. Aided (ATF/GTT)
3. Automatic

E. Passive Track (Normal and Degraded System Operation)

1. Manual (MTB)
2. Aided (ATF/GTT)
3. Automatic

F. Active Classification

G. Passive Classification

H. Contact Reporting/Communications

I. No Echos

J. Lost Contact (Active and Passive)

K. Regain Contact (Active and Passive)

L. Multiple Echo/Target (Active and Passive)

M. Attack (Active and Passive)

For each of the procedures listed above, it is necessary to precisely define each operator action and system reaction as shown in the example in Table 5. This procedure was written for Configuration Alternative 1 and would contain different steps if developed for Configuration Alternative 2 (see the following subsection).

Similar sequences are required for each procedure listed above. Procedural development should reflect consistency with standard physical relationships found in operational sonar systems.

TABLE 5. EXAMPLE OF GenSOT DEVICE OPERATING PROCEDURE FOR SYSTEM SET UP, TURN ON, INITIALIZE

Procedure for Set Up for Active Search, RDT, Normal
A. Set XMIT controls as follows:
1. Set COVERAGE to RDT
2. Set XMIT frequency to 4.5 kcps
3. Set PULSE LENGTH to 30 ms
4. Set BAND WIDTH to ________
5. Set POWER OUTPUT to 140 dB
6. Set TYPE to CW
7. Set PATH for best detection probability as per sonar message
8. Set RANGE to 20 kyd
9. Set ARRAY to SPHERICAL
10. Set D/E ANGLE to -10°
11. Set SECTOR CENTER to 0° (off)
12. Set SECTOR WIDTH to 2.5° (off)
B. Set RECEIVE CONTROLS as follows:
1. Set FREQUENCY BAND to 100 Hz to 1 kHz
2. Set BAND WIDTH to _______
3. Set SIGNAL PROCESSING to HETRODYNE
4. Set BEAM WIDTH to _______
5. Set ARRAY to SPHERICAL
6. Set INTEGRATION TIME to OFF
7. Set FILTERS to OFF
8. Set SOUND VELOCITY to value from sonar message

TABLE 5. EXAMPLE OF GenSOT DEVICE OPERATING PROCEDURE FOR SYSTEM SET UP, TURN ON, INITIALIZE (Continued)

C. Set AUDIO controls as follows:

1. Set TYPE to ANALOG
2. Set OUTPUT to desired output
3. Set MODE to PREFORMED BEAM
4. Set Sum-Difference to SUM
5. Set GAIN to OFF
6. Set AGC to OFF
7. Set CRT format to PPI
8. Set CRT DISPLAY CENTER to SCD
9. Set TRUE/RELATIVE to TRUE

D. Set INTERFACE CONTROLS as follows:

1. Set ATF to OFF
2. Set ON TARGET to OFF
3. Set SEARCH to SEARCH
4. Set OWN SHIP'S SPEED to proper value
5. Set TAPE RECORDER to OFF

E. Set TRACKING CONTROLS as follows:

1. Set MTB to ON
2. Set GTT to OFF
3. Set MCC to OFF
4. Set AUTO TRACK to OFF

F. Depress SYSTEM POWER to ON

Check for the following:

1. POWER LIGHT goes ON

TABLE 5. EXAMPLE OF GenSOT DEVICE OPERATING PROCEDURE FOR SYSTEM SET UP, TURN ON, INITIALIZE (Concluded)

2. PM/FL FAULT readout shows all zeros
3. CRT display contains PPI format
4. Power output meter reads 140 dB
5. JOYSTICK functions in RANGE and BEARING
6. RANGE and BEARING displays track JOYSTICK
7. Gyro light is OFF

G. Adjust AUDIO GAIN and CRT CONTROLS to attain best detection display

H. Commence SEARCH PROCEDURE according to ship doctrine

SECTION IV

GenSOT DEVICE PANEL LAYOUT

CONFIGURATION ALTERNATIVES

Two configurations for a GenSOT device were developed for this program. The first alternative was configured to closely parallel the appearance of an operational sonar (Figure 4). The second was designed to provide all the necessary functions, but there was no attempt to provide the high-panel fidelity contained in Configuration 1 (Figure 5).

Selection of a configuration for evaluation of the GenSOT concept should be based on system operation rather than appearance. Both Configurations 1 and 2 provide the capability for supporting the objectives of GenSOT. The major difference between configurations is the approach used to implement various system functions and displays.

Simulation Fidelity

Simulation fidelity for a GenSOT device refers to the salient features of all sonar systems. The broad range of sonar system console shapes, sizes, layouts, and control/display types provides a continuum of possible configurations for designing a GenSOT device. One selection approach was to make a comparative analysis of each feature for each system in the sample and select a single, "most representative" definition. That approach was considered but discarded on the basis of practicality and potential payoff.

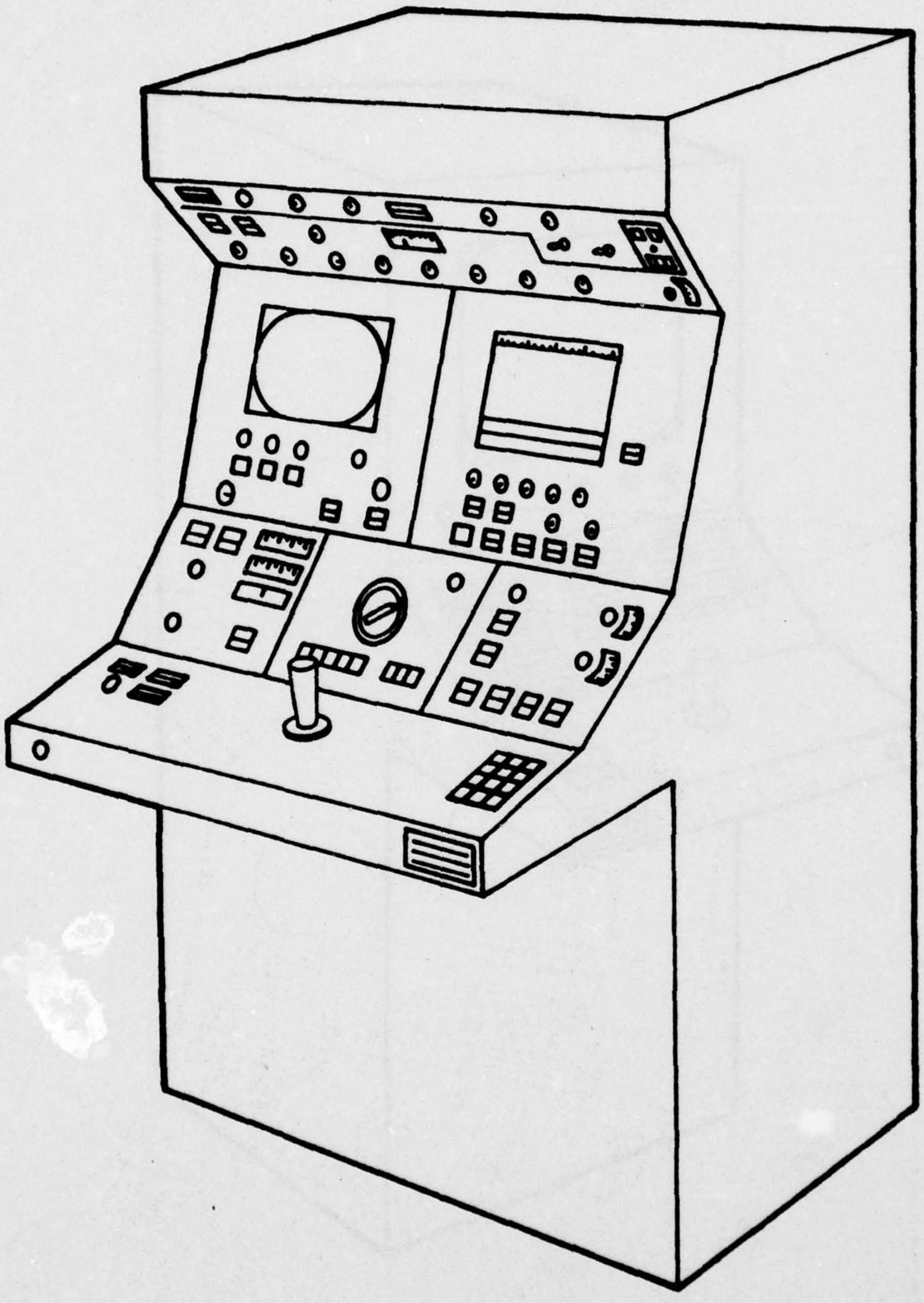

Figure 4. GenSOT Configuration Alternative 1

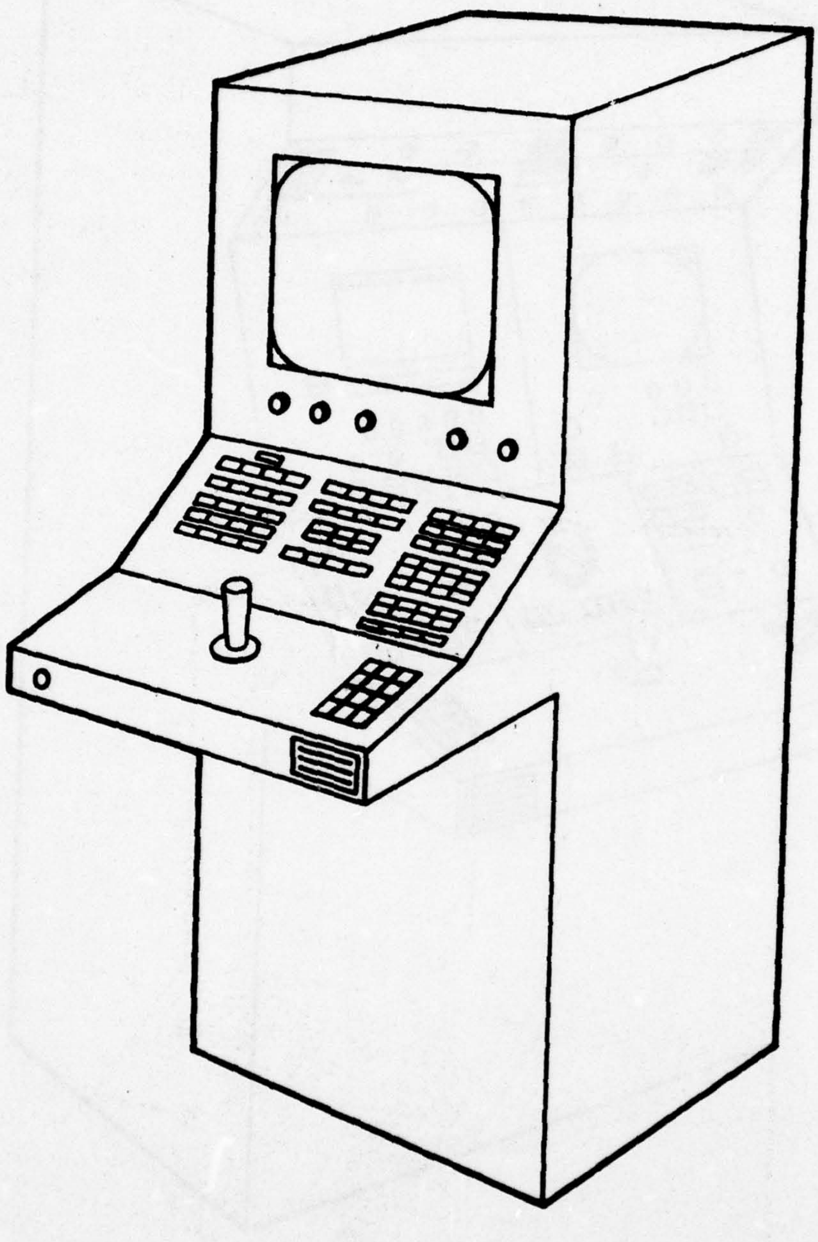

Figure 5. GenSOT Configuration Alternative 2

An inspection of characteristics of sonar consoles to identify types of controls and displays currently in use indicated that there was little commonality. The position taken was that GenSOT device console shape, dimensions, control/display layout, and types should be defined on the basis of representativeness rather than accurate duplication of real-world systems. Specifically, our goal was to provide the trainee with manipulanda and displays to train the salient general features of the job. No attempt was made to identically copy the size, shape, type, layout, or feel of any operator console or control/display set currently in use.

We took a somewhat different position in dealing with the factors of control/display interactions and display formats. Since operator trainees must learn the relationships between controls and between controls and displays to successfully complete GenSOT or current Class A ST training, the issue of fidelity for GenSOT device control and display interactions and display formats could not be addressed in the same manner as console shape; rather, simulation fidelity for a GenSOT device control-control and control-display interactions was based on the actual interactions found in operational sonars.

The specification of GenSOT device display format fidelity was more straightforward. Common display formats were identified and recommended for inclusion in the GenSOT device (see Table 4). Fidelity requirements for displays fall into two major areas: first, the fidelity of signals used to stimulate the displays and, second, the capability of the displays to reproduce those signals. Further, the impact of own ship's motion, stated environmental conditions, and control settings must appear to interact in producing a signal which is correctly responsive to those factors. Here an important feature for training is signal strength. Although

operators frequently operate their systems on the fringes of signal detectability, such fine discriminations are not required for GenSOT. Instead, the emphasis is on properly setting controls for targets of any strength.

The fidelity requirements for visual and audio signals are similar. However, for visual signals there is an added requirement for multiple display formats. The fidelity objective is to provide the trainee with a basic knowledge and understanding of:

- Format appearance, and
- Format use for search and tracking operations.

Adequate fidelity requires accurate format content and dynamic characteristics. However, exact replication of a specific sonar display is neither needed nor appropriate for the GenSOT system.

Selection of display hardware was also based on approximating operational sonar systems while providing a faithful reproduction of the input signals. Many commercially available audio equipments, meter movements, CRT's, and paper chart recorders meet the needs associated with the GenSOT device. An additional consideration which should influence selection of specific hardware is that of reliability and maintainability. Because of the importance of having any training device continually available, these factors must play a major role in the selection process.

Finally, the major trade-off which should govern the development of engineering specifications for a GenSOT device is that of cost vs. training effectiveness. This trade-off begins with the preparation of the solicitation

for developing and building the device and continues throughout the production process. Our experience in designing and building military training equipment suggests that economies can be affected in the design of such systems without significant impact on training effectiveness. The major determinant of whether such economies are possible is the degree to which the design and fabrication is controlled by MIL-SPEC and MIL-STD requirements vs. best commercial practice. Based on our experience, the best commercial practice approach is highly effective.

RECOMMENDED GenSOT DEVICE CONFIGURATION

In this subsection we will discuss two alternative GenSOT device configurations. Several factors led to our recommendation of Alternative 2 (Figure 5) as the configuration for an experimental GenSOT device. A major factor influencing our recommendation was that of the trade-off between projected costs and utility of the two alternatives.

Expanded views of Alternative 1 are shown in Figures 6 through 9. Figures 10 and 11 are expanded views of Alternative 2. The push-button legend for Figure 10 is the list of parameters in Table 3.

The major differences between Alternatives 1 and 2 are:

1. Superficial fidelity,
2. Number of controls and displays,
3. Method of controlling system functions, and
4. Projected costs.

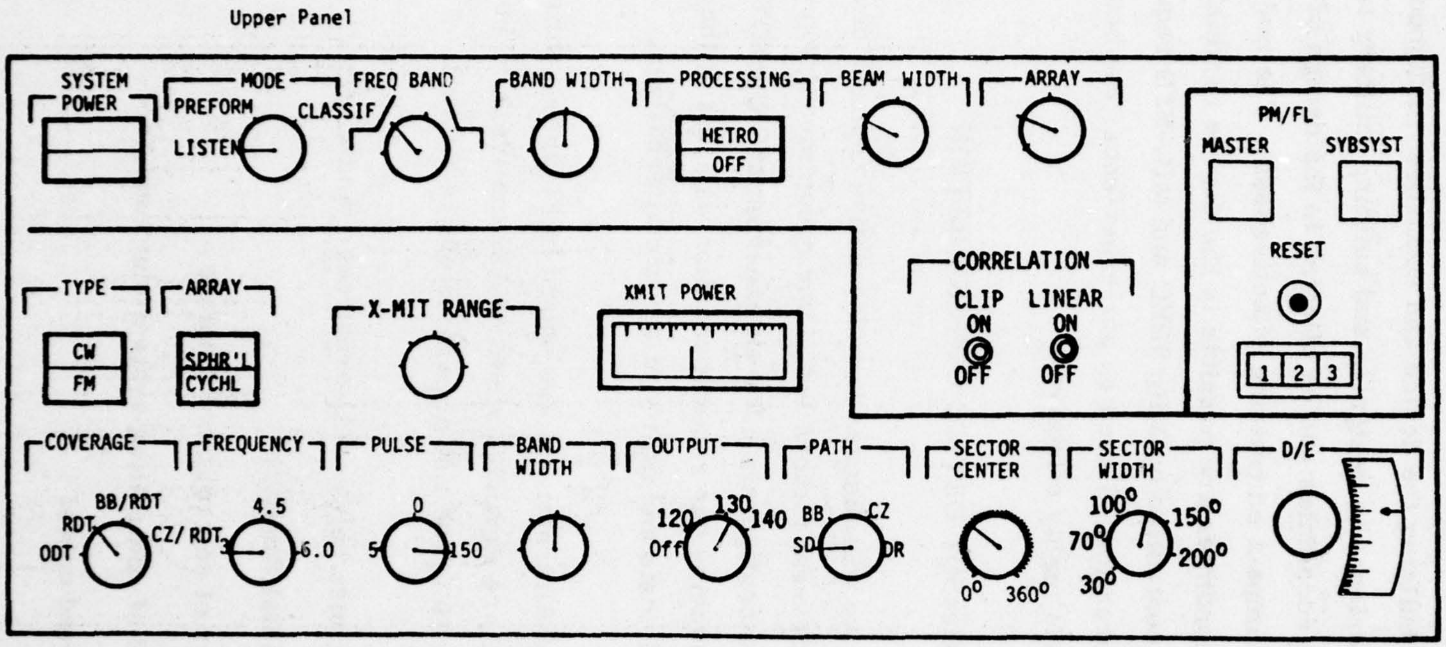

Figure 6. Upper Panel of Configuration Alternative 1

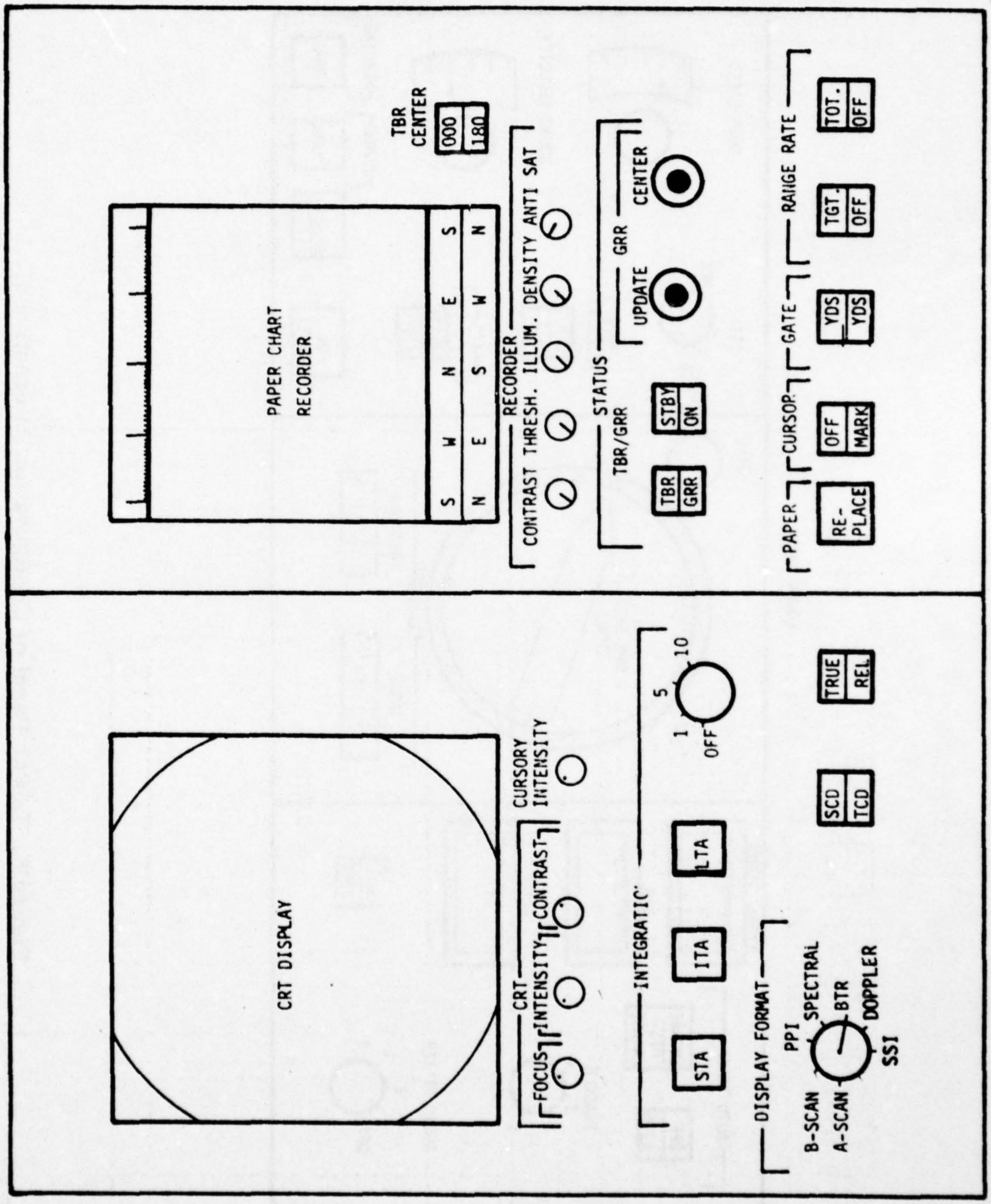

Figure 7. Display Panel of Configuration Alternative 1

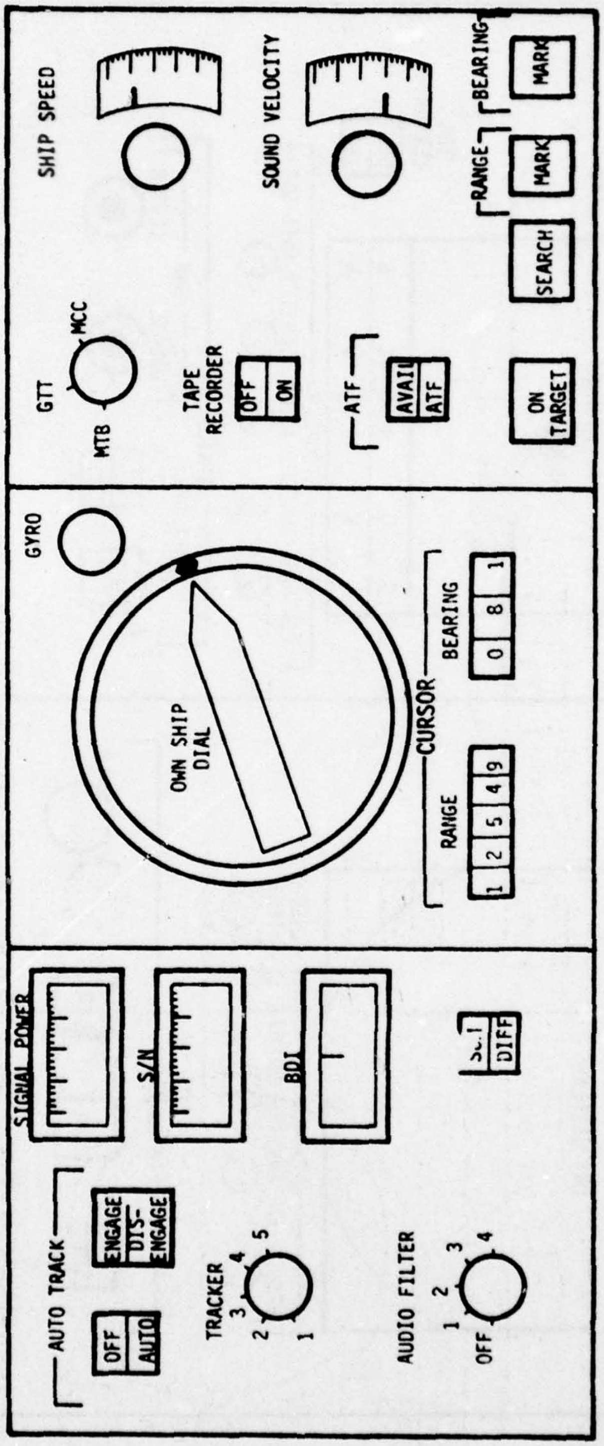

Figure 8. Lower Panel of Configuration Alternative 1

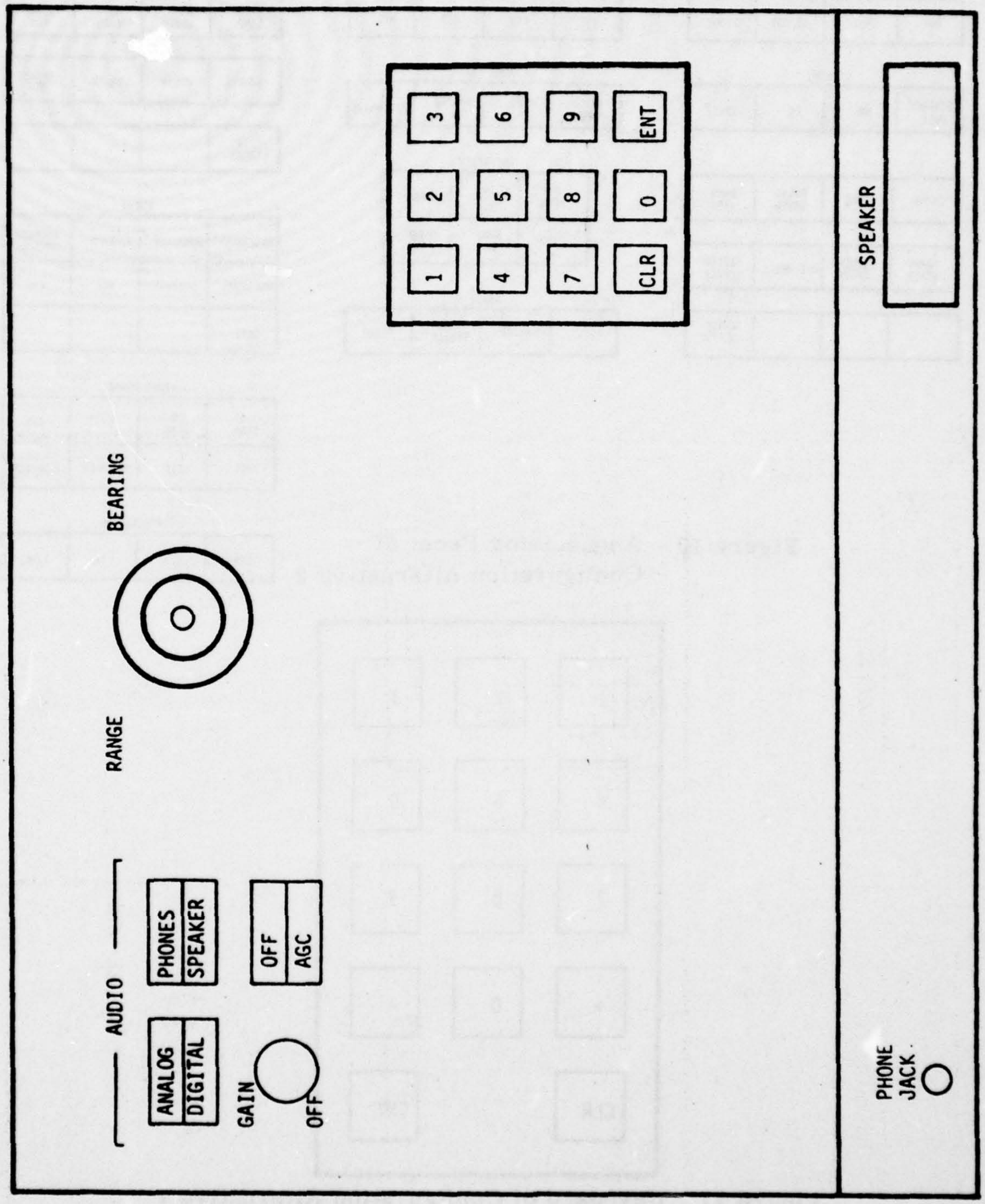

Figure 9. Shelf and Bullnose of Configuration Alternative 1

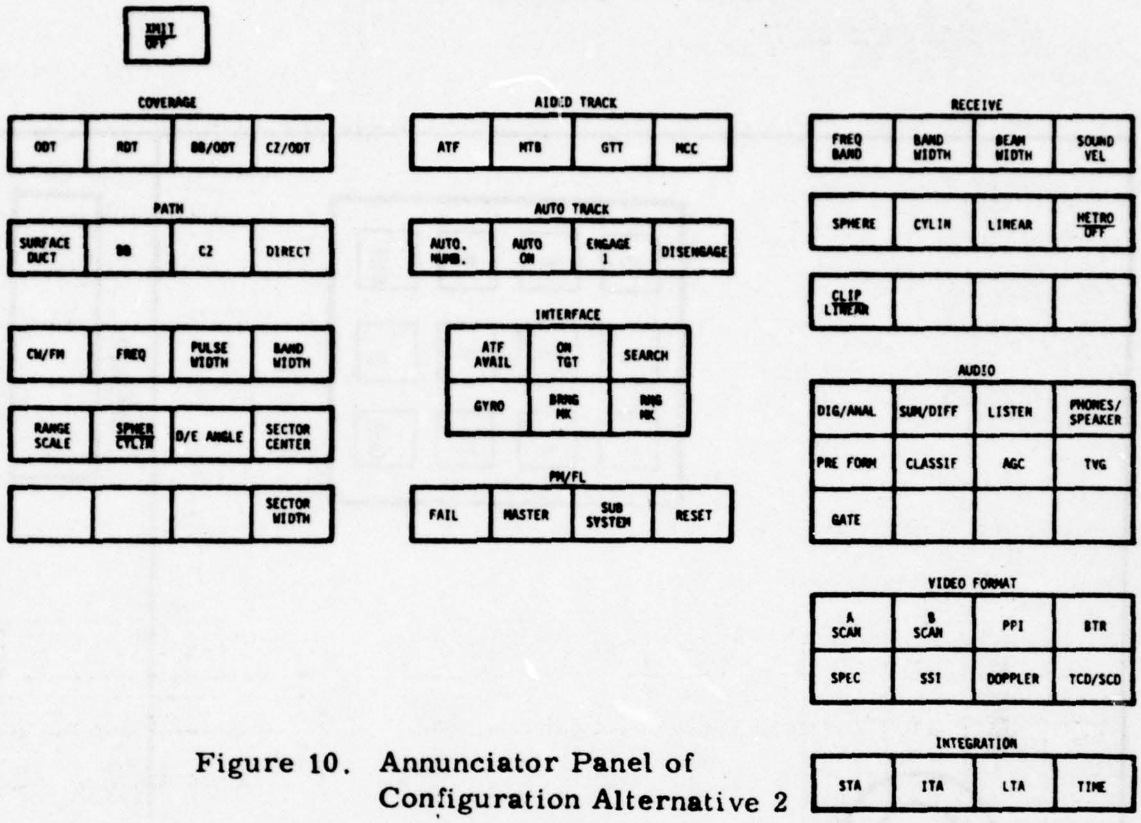

Figure 10. Annunciator Panel of Configuration Alternative 2

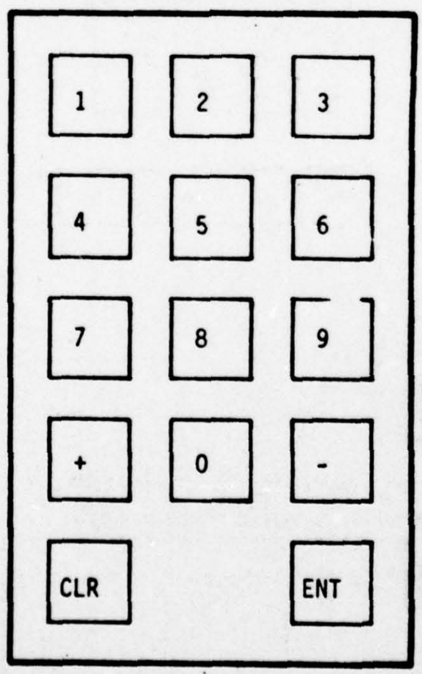

Figure 11. Keyboard of Configuration Alternative 2

Although both alternatives provide the same capability for initiating and controlling GenSOT system functions, Alternative 1 (Figure 6) possesses substantially more resemblance to the "classical" operational sonar system. Additionally, Alternative 1 possesses more controls and displays than Alternative 2 and requires different actions from the operator in order to manipulate system status. In addition to simple push-buttons, Alternative 1 involves the frequent use of rotary switches, meter movements, own ship's dial, etc.

The impact of such variables (e.g., fidelity, controls and displays, and control method) upon the effectiveness of training is not known. However, we hypothesized that if negative transfer were to occur from GenSOT to the operational environment it would be greatest for Alternative 1. Alternative 2, although bearing some resemblance to one passive system (BQQ-5), provides less opportunity for negative transfer. Thus, from an appearance standpoint, Alternative 2 is preferred.

Accomplishing sonar system control involves following dictated operating procedures. This is true for both GenSOT device configuration alternatives as well as for operational systems. The impact of the two GenSOT alternatives on the types of procedures required for system control is clear. Alternative 1 will require manipulation of several control types coupled with interpretation of multiple displays. For Alternative 2, control will be achieved through button presses. Furthermore, Alternative 2 will require more procedural steps to accomplish a given configuration. For Alternative 1, a rotary switch is set to a given position; for Alternative 2, the function and setting must be selected and the data must be entered.

The factor of system cost for Alternatives 1 and 2 reduces to the cost of simulation hardware. This is true because the computer, operating system, and software required are the same for both alternatives. The basic issue is the cost to design and build the GenSOT device consoles. Without an engineering design, it is not possible to precisely determine console costs. However, based upon the type and amount of components specified for the alternatives, we believe Alternative 1 would be more costly.

Based upon consideration of the differences between Alternatives 1 and 2, we feel that Configuration Alternative 2 is the most appropriate for the GenSOT device design.

SECTION V

GenSOT SYSTEM DESIGN PHILOSOPHY

METHOD OF INSTRUCTION

The rationale which underlies the approach to the GenSOT system involves the elements of: assessment of the training needs, development of the training program, conduct of the program, and evaluation of its efficacy. It is proposed that, given the objectives of GenSOT and their relationsh- 'o the ASO training pipeline, computer aided instruction (CAI) techniques be used. There are a number of benefits to be gained from this approach--namely,

- Hands-on training,
- Integration of theoretical concepts with performance training,
- Performance measurement and criterion referenced feedback, and
- Standardization of training methodology, subject matter coverage, and trainee proficiency.

There are other advantages touted for CAI, such as individualization of instruction and liberating the instructor to teach.[8] However, these together with use of higher order languages, artificial intelligence, adaptive training,

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[8]Goldstein, I. L., "Training: Program Development and Evaluation," Brooks/Code, Monterey, California, 1974.

and branching programs are among the least cost-effective features of CAI.

The emphasis of the GenSOT program should be upon drill and practice of the functional procedures of the ASO's job. The overall training goal is the mastery of relatively fixed procedures or families of procedures and the integration of classroom-acquired knowledge into those procedural tasks. The procedures are not only sequences of motor activities but include supporting elements of inferential and deductive activities. The trainee is required to apply knowledge of data, rules, and relationships to "if-then" problems in which he must think from a set of existing or given conditions to consequences, outcomes, or subsequent procedural steps.

The training environment shall be characterized by the level of simulation necessary to evoke critical job behaviors. Feedback should be provided in accord with the criteria for successful shipboard performance. To reiterate, the objective of the GenSOT experience is to integrate the theoretical concepts of the acoustic sensor environment with the operational behaviors required in the fleet.

Feedback requires the analysis of the responses and steps within a procedure to identify a) correct responses and errors serious enough to warrant feedback, and b) the type and content of feedback to be provided. While the GenSOT simulator will be predominantly a performance device for drill and practice, some conceptual-verbal content should be presented in feedback. For example, some feedback should provide diagnostic information concerning specific erroneous responses and their consequences or alternatives.

Performance evaluation within the GenSOT system is based on the execution of each operational scenario (see following subsection for details). A performance criterion for each procedure must be defined in terms of performance time and/or a minimum number of errors or deviations from specified standards. The trainee will then be required to pass this performance criterion before moving on to the next training exercise or unit.

Additional performance data provided to the instructor include information on a student's level of mastery of a procedure or unit of instruction and a summary of his performance in terms of time and errors.

Sequencing of instructional material is an important part of an instructional strategy. The model of the subject matter that has been generated permits demonstration of the relationships between procedures and training objectives. As each instructional module is developed, the prerequisites for that module must be identified. These prerequisites fall into two categories: informational elements to be learned in classroom instruction, and procedures or other skills which will have been learned on the trainer prior to the specific module.

Implicit in the above is a model of the trainee. That is, the instructional program must interrelate with the characteristic educational backgrounds, aptitudes, GCT scores, etc. of the trainee population. Only by consideration of these factors can GenSOT have the desired impact of minimizing training time without loss of trainee quality.

TRAINING SCENARIOS

Scenarios are the backbone structure for instruction at the GenSOT console. Such scenarios must contain detailed instructional messages and performance feedback which are presented to the student in CAI formats, thereby providing the framework for attaining the training objectives.

A typical training scenario begins with a statement of the training objectives for that lesson. This message appears on the CRT following student sign-in at the console. The student then indicates that he understands the training objective by depressing the specified key on the input keyboard. If the objective is not understood, the student can request clarification by depressing a different key. If the student still fails to understand the objective, he is instructed, by way of the display, to summon the instructor. This process is summarized in Table 6. (For this discussion we assume that the student's console is configured as GenSOT Device Alternative 2.)

Once the student has acknowledged an understanding of the training objective for the lesson, the system displays a reference to the information in a special GenSOT training manual. This information is prerequisite to satisfying the lesson's training objective. The student is then quizzed by the system (multiple choice and true-false questions) to ensure that he has grasped the prerequisite material and to determine his pretest level. The student's responses are scored and filed by the system. At the end of the training session a second test is given and the student's scores are displayed to the student. The instructor receives a printout of all students' gain scores for the current lesson plus a cumulative mean score for all lessons which have been completed.

TABLE 6. STEP 1. PRESENTATION OF TRAINING OBJECTIVE

Student Action	System Response
Enter serial number	Display training objective
Objective not understood Enter "HELP"	Display expanded objective
Clarification not understood Enter "HELP"	Instructor is summoned to student's console
Student ready to proceed Enter "STEP"	(The system displays the next step)

If the student answers the questions correctly, he gains access to the next lesson step. If questions are not answered correctly, remedial instruction is given on the display. When the student indicates that he now understands the material, he is quizzed again and his scores are recorded by the system. If the student indicates that even after presentation of the remedial material he still does not understand, he is referred to the training manual reference and the instructor is alerted. This same outcome would occur if the student failed to pass his second quiz. When the student passes a quiz or indicates that he has completed his review of the training manual reference, the next step in the lesson is presented. The sequence for the second step in the lesson is summarized in Table 7. At the completion of this step, the student

TABLE 7. STEP 2. KNOWLEDGE OF PREREQUISITE MATERIAL

Student Action	System Response
Enter "STEP"[1]	Display reference to training manual (TM). Questions are displayed.
Keys in answers	If the student makes a passing score, he proceeds to Step 3. If he does not make a passing score, remedial information is displayed. System stores the score.
Enter "STEP"	Questions are displayed.
Keys in answers	If a student makes a passing score, he proceeds to Step 3. If he does not make a passing score, he is instructed to review TM. System stores the score and alerts instructor if quiz was not passed. Enter "STEP" after TM review or Enter "HELP" to summon instructor.
Enter "STEP"	

[1]This is the last step in Table 6.

is prepared to begin actual generalized training. Mastery of the material in the training manual has prepared the student for a formal exercise in some aspect of sonar system operation.

The third step in the lesson begins with a statement of the problem which the student will learn to solve before the lesson ends. The problem will be structured so that some or all of the lesson's training objective will be met. Sometimes more than one problem will be used to satisfy the lesson's training objective. Each problem will contain information or a "given." This information and the knowledge acquired in prior lessons will allow the student to correctly solve the problem.

For example, the student at some point in the training sequence will have learned that certain environmental variables such as salinity and water temperature have an effect on the transmission of acoustic energy through water. He will also have learned that there are different search modes and appropriate uses for each of them. The problem presented to the student will contain sufficient information to specify a particular GenSOT console configuration. Achieving this correct configuration will require the student to integrate the problem's "given" with his prior knowledge to obtain the correct solution to the problem.

Each problem will require the student to perform a series of steps in a particular sequence. On the student's first attempt to solve the problem, he will be aided by the system. After reading the problem statement, the student will select and actuate or enter a mode, or variable, or parameter. If he makes the correct action, the system will respond as follows: "Good. You have correctly selected (mode, etc.) because...." The system will

then give the correct reason for the selection. If the student's action was incorrect, the system states this and gives the correct action and the reason why it was correct. The student then corrects his response and proceeds to the next step. The system scores and stores the student's responses. If the student does not understand the reason given by the system for the correct response, the student can summon the instructor for additional clarification.

When the student has finished with the problem and is satisfied that he understands the solution, he is given a second problem. This problem requires the same knowledge and skills as the problem he just completed. However, for the second problem, there is no coaching from the system. The only system feedback is an indication of the correctness of the student's responses. The system again scores the student's responses. If the student's score is below a defined cutting score, the instructor is summoned to recommend the appropriate remedial action. Since each scenario builds on the knowledge and skill from the previous scenario, it is important for the student to grasp the concepts and relationships represented by one scenario before proceeding to the next.

In summary, the scenarios consist of four parts:

- The training objective,
- Knowledge of prerequisite information,
- System aided problem solving, and
- Unaided problem solving.

The scenarios provide the structure for the lessons while the training objectives provide the overall framework for the GenSOT course of instruction. The system provides performance evaluation information which indicates the need for remedial instruction for individual students or for the entire class.

SYSTEM ARCHITECTURE

Although the concept for a GenSOT simulation system is still emerging, certain specific features of that concept are known and permit a preliminary system architecture to be discussed. The architecture discussed here is predicated on two major assumptions:

1. The GenSOT system design should accommodate the training pipeline envisioned as the ultimate use level.
2. GenSOT system design should be capable of future expansion to incorporate additional student stations.

Based upon substantial previous experience in the design of multi student station training systems, the task of developing a conceptual design reduced to the trade-off between a multi-minicomputer vs. a microprocessor based system. Use of a microprocessor based system is certainly feasible but its utility is constrained by the major factors of requirements for:

- Amount of input/output data transfer,
- Speed of operation,
- Cost of system design, acquisition, and support, and
- Overall system requirements.

With these factors in mind, a purely microprocessor system would conceptually appear as in Figure 12. The main microprocessor system could contain as much as 64K core memory supplemented by a mass memory unit (floppy disc). Addition of the disc capability would substantially increase the storage capacity of the system but in turn would require a controller for formatting data on the disc.

Ideally, a general purpose but specially built interface unit would be obtained to allow the main microprocessor to communicate directly with student station(s)' microprocessor. A majority of the interface software could be contained in the main computer which would allow for additional storage of student station software in the student station microprocessor system. The student station microprocessor system would interface directly to the simulation hardware and would probably only require sufficient memory for one CRT display page or frame. It is entirely possible that the CRT unit could be selected to contain a memory capability in which case the total microprocessor memory could be used for data collection (e.g., student performance). Specific memory size and system speed requirements will be dictated by the size of the courseware/simulation package associated with the GenSOT system and by the number of student stations in the system.

A second alternative hardware system architecture for a GenSOT device is that involving a combination of minicomputer and microprocessor (see Figure 13). The advantages of this approach over the pure microprocessor architecture are:

- Central minicomputer can be programmed in FORTRAN making software modification more convenient.

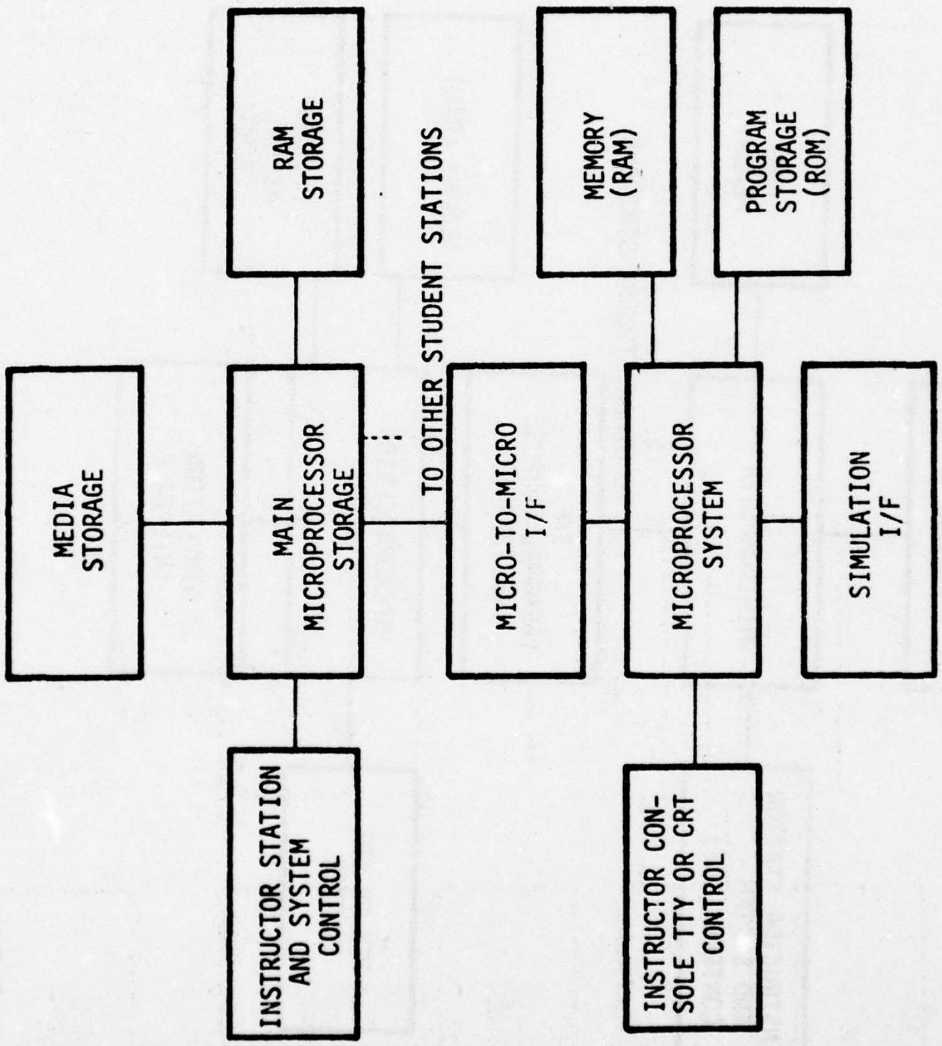

Figure 12. Microprocessor Based System Concept

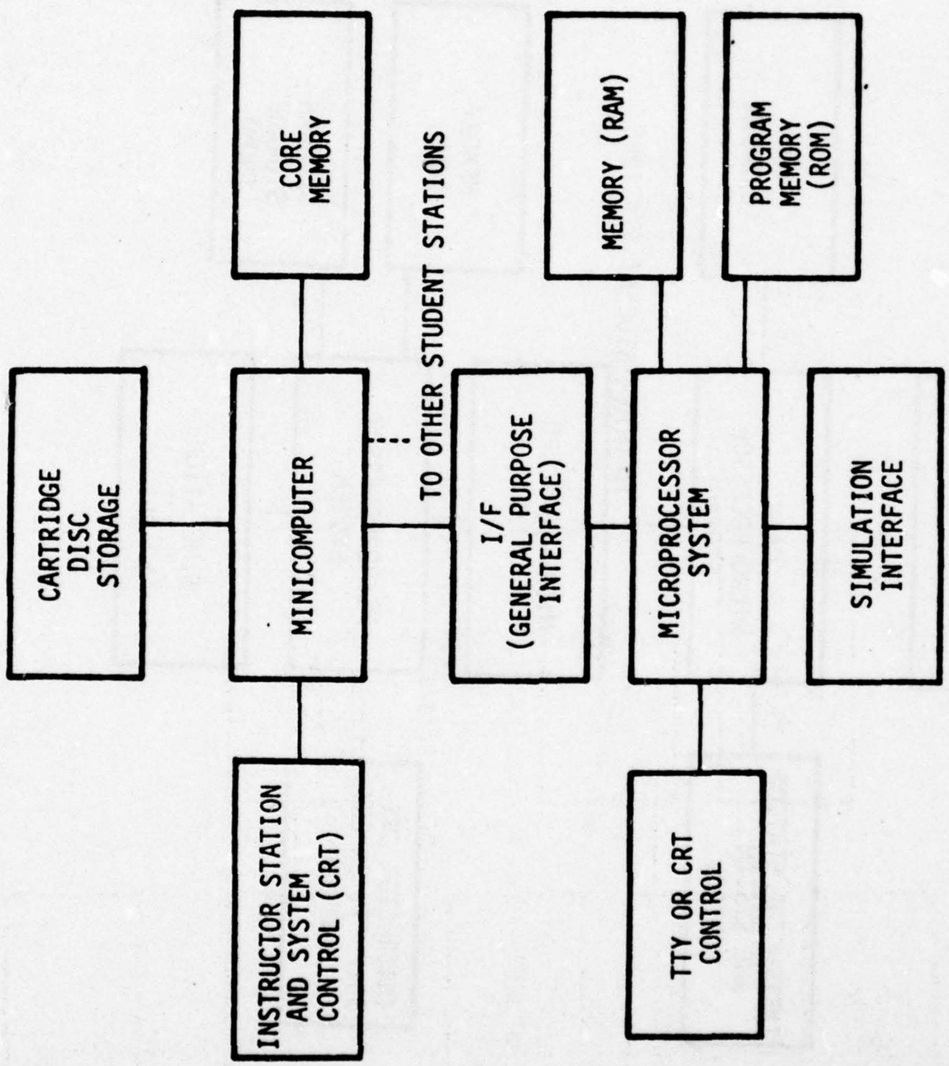

Figure 13. Minicomputer Based System Concept

- The central minicomputer concept provides a larger memory capacity than that available using a purely microprocessor system.

It must be recognized that this discussion of using a microprocessor type architecture does not imply that a single microprocessor chip is involved. The microprocessor systems discussed above consist of a central processing unit, read only memories, random access memories, peripheral interface adapters, data and bus extenders, modems, an asynchronous communication interface adapter, etc. While certain of these system components are currently available, design into a total system configuration would still be required. Additionally, software must be developed. That software will involve some unique languages which can be predicted to increase developmental costs over those for a multi minicomputer approach.

A multi minicomputer architecture is appealing for several reasons. First, and perhaps most importantly, such systems have been used and are available with little developmental effort. Second, the software design and programming task would be substantially easier than a total microprocessor alternative. However, there is a need to carefully explore the trade-off between hardware/software developmental costs of microprocessor vs. minicomputer based systems prior to making a final selection. That trade-off must consider supportability, maintainability, and modification factors in addition to initial acquisition costs.

On a preliminary basis and considering the factors discussed above, the preferred hardware architecture for a multi student station GenSOT system is that of a combined minicomputer/microprocessor architecture. This

selection is based on the belief that, by combining the advantages inherent in both the mini central processor unit and microprocessors as peripheral units, a highly flexible, easily used and maintained system can be developed.

SECTION VI

GenSOT SYSTEM MANAGEMENT

STUDENT SELECTION

The element of student selection as it relates to GenSOT is considered from two standpoints: concept evaluation and impact upon ASO proficiency. An anticipated trend with the shift to the all-volunteer force was a reduction in the level of trainee input capability and aptitude. Further, the sonar systems being introduced into the fleet are of greater complexity than those of the past. The implication is that less capable individuals may be called upon to operate more difficult systems.

Selection criteria for ASO's continue to emphasize maintenance aptitudes as measured by the Navy Arithmetic Reasoning and Electronic Technician Selection tests, and auditory skills as measured by the Sonar Pitch Memory Test. These selection criteria do not reflect the changes and potential changes in sonar suite manning and operator task requirements stemming from these system developments. Mackie et al. (1975)[9] suggest alternative selection criteria which may more accurately reflect the job requirements of the ASO of the future. GenSOT must be responsive to the level of capability possessed by the trainee in order to provide adequate training as well as provide high proficiency ASO's for the fleet.

A second consideration in student selection is in trainee sampling and in group assignment for concept evaluation. The target population as des-

[9] Mackie et al., op. cit.

cribed above must be representively sampled. Further, trainees must be assigned to experimental groups such that capabilities are matched between trainees in the various groups. While current selection criteria may be used to select the total sample, a pretest based upon the training objectives of the common core course is required for the matching process.

TRAINING SCHEDULE

Background

The value of generalized ASO training and the use of a GenSOT device is contingent on the prior acquisition of knowledge, on the knowledge which is concurrently acquired with skill training on the training device, and on quantity, quality, and type of specific knowledge and skills which will be acquired following generalized training (specific system training). Optimizing the value of generalized ASO training will cause some changes in the overall training schedule (following basic recruit training).

There are several factors which have a major impact on the ASO training schedule although they are not methodological training considerations which relate specifically to GenSOT:

- Four- and six-year obligors,
- ASW School recommendation for a longer "A-1" course,
- The Navy Enlisted Occupational Classification System (NEOCS) Study's recommendations for reduced first enlistment training, and
- The magnitude and type of role for specific system training and for on-the-job training (OJT).

Our objective is to fit generalized ASO training into the training sequence to maximize its potential benefits. However, it would be unrealistic to ignore the above considerations. Therefore, we offer training schedule alternatives which take these factors into account. These scheduling alternatives are reflected in the evaluation plans which are discussed in the next section. Before considering the training sequence alternatives, we will briefly discuss the impact or potential impact of the factors listed above.

The first factor is concerned with the present differences in training for four- and six-year obligors. The essential difference (for Surface Sonar Technician training for example) is that six-year obligors receive a minimum of 34 weeks of training (and often much more) prior to sea duty. The six-year obligor receives six to eight weeks of E&E training, about 14 weeks in an "A-2" course followed by 4 to 27 weeks in a "C" course. This is training beyond the 10 weeks in the "A-1" course received by the four-year obligor.

The increasing complexity of new sonar systems (e.g., BQQ-5) and other factors have caused the ASW School to recommend an increase in the length of "A" level training for four-year obligors. A much broader set of considerations resulted in the recommendations contained in the NEOCS study. NEOCS assumes that about 90 percent of first enlistments will be for three years. During these three years, there will be little formal training with the implication that initial training will be quite generalized (intensive training would occur following re-enlistment). During the first three-year enlistment, increased reliance would be placed on OJT, creating requirements for generalized training and improved shipboard training subsystems, as well as more effective use of these subsystems.

There is another factor which we believe deserves consideration with respect to generalized "A" School training and OJT. For various reasons, including the recent fuel shortage, much more of the fleet is now pierside. The training resource represented by the pierside fleet has not been fully exploited. In the alternative training sequences discussed below, we suggest potential use of this resource. While we recognize that there could be well-founded objections and considerable resistance to changes in the ASO training schedule, we believe that there are compelling reasons for considering schedule change:

- The NEOCS study's recommendation (less initial training) and the contrary recommendation from the ASW School (more initial training) suggest that there is broad recognition of the possibility that training schedule changes of some kind might lead to improvements.

- Our motivation for change does not directly stem from a study of the training schedule. Rather, it concerns the placement of GenSOT in the series of steps which lead to qualified ASO's. Our concern is the possibility of improving training effectiveness through training schedule changes.

- Later in this study we show that the duration of training (operating through personnel costs) has a major impact on the cost of training. A more efficient schedule would have a clear benefit with regard to cost.

The evaluation of GenSOT would not depend on OJT of any kind. Specific sonar system training would require only facilities which are now in use during "A-1" level training.

A major difficulty in the consideration of alternative training schedules, which would be used in preparing the evaluation plans, is the lack of correspondence between surface and subsurface "A-1" level training. The subsurface training schedule provides for about 15 weeks of core phase training and about four weeks of operational training. In comparison, surface "A-1" training devotes only six weeks to the core phase and three to five weeks to operational training using specific sonar trainers.

For the purpose of evaluating GenSOT for both surface and subsurface ASO training, we suggest a revised subsurface "A-1" level training schedule of ten weeks duration. This schedule is comparable to the surface ASO's training schedule. In Table 8 we show the number of periods devoted to each topic for the current subsurface 19 weeks of "A-1" training and the number of periods by topic for the modified ten week "A-1" training schedule. The 19-week subsurface schedule was reduced by deleting topics and by shortening other topics. While it is likely that the shortened schedule will not result in as proficient subsurface ASO's as the current schedule, it would be of some interest to measure the magnitude of this difference during the GenSOT evaluation phase.

TABLE 8. SUBSURFACE CORE TRAINING REDUCTION

Phase I	Periods 19 Week	10 Week
Introduction and Indoctrination	2	2
Security	1	1
Submarine Divisions and Operations	2	2
Electrical Safety Precautions	3	3
Pressure Test	4	4

TABLE 8. SUBSURFACE CORE TRAINING REDUCTION (Continued)

Phase I (continued)	Periods 19 Week	10 Week
Resuscitation	3	3
Exponents	1	1
Logarithms	2	1
Decibels	7	1
TV-3/TV-7	2	0
AN PSM-2A	1	0
CAQI 200 CD	2	0
Simpson 260	3	1
AN/USM-115	2	0
ME-6 D/U	1	1
AN/USM-140	6	3
AN/USM-245	2	0
Test Equipment Lab	8	4
Test Equipment Practical Exam	8	2
Phase I Exam and Review	3	2
SAQ	5	2
General Military Training (GMT)	4	2
Phase I Subtotal	72	35
Phase II		
Circuit Symbol & Name Plate I. D.	2	0
Equipment Technical Manuals	2	0
Electron Tube Characteristics/Operation	4	0

TABLE 8. SUBSURFACE CORE TRAINING REDUCTION (Continued)

Phase II (continued)	Periods 19 Week	10 Week
Power Supplies, Tube Type	4	0
Amplifier, Tube Type	4	0
Amplifier Coupling	3	0
Power Supply and Amplifier Lab	10	0
Oscillators	4	0
Multivibrator	3	0
Multipurpose Tubes	4	0
Phase II Exam and Review	3	0
SAQ	3	0
GMT	2	0
Phase II Subtotal	48	0
Phase III		
Transistors/Transistor Lab	8	0
Synchros	7	0
Hand Tools and Techniques	6	0
Transistor Practical Exam	7	0
Phase III Exam and Review	2	0
SAQ	2	0
GMT	2	0
Phase III Subtotal	34	0

TABLE 8. SUBSURFACE CORE TRAINING REDUCTION (Continued)

Phase IV	Periods 19 Week	10 Week
The Planned Maintenance System	6	4
Physics of Sound	8	8
Tactical Use of Sound	6	6
Noise Reduction	4	4
Hydrophones and Transducers	3	3
SAQ	2	2
GMT	1	1
Phase IV Subtotal	30	28
Phase V		
Introduction to Turncounting	4	3
Ship's Propulsion Systems	2	2
Introduction to Cargos	2	1
Introduction to Warship Class	3	2
Introduction to Lightcraft Class	3	2
Introduction to Submerged Sub Class	8	3
Student Interview Sheets	1	1
Classification Practice	3	3
Sub Operating Mode Changes	1	1
F.A.C.T.S.	1	0
ZIG Detector	2	0
Introduction to Non-Target Sounds	3	3
Classification Practical Exam	4	3

TABLE 8. SUBSURFACE CORE TRAINING REDUCTION (Continued)

	Periods	
Phase V (continued)	19 Week	10 Week
Phase V Exam and Review	3	3
SGRT	3	2
GMT	2	2
Phase V Subtotal	45	31
Phase VI		
AN/UNQ-7E	5	0
RYCOM	2	0
DUUG-1B	5	0
AN/UQN-1H	8	0
AN/BQH-1B	7	0
AN/BQA-8	6	0
AN/BQC-1A	7	0
UQC-1G	8	0
WQC-2	13	0
Phase VI Exam and Review	3	0
SRGT & SAQ	9	0
GMT	4	0
Phase VI Subtotal	77	0
Phase VII		
Introduction to BQS-13	1	1
BQS-13 Software	4	2

TABLE 8. SUBSURFACE CORE TRAINING REDUCTION (Continued)

Phase VII (continued)	Periods 19 Week	10 Week
BQS-13 Hardware Lab	3	2
BQS-13 Hardware	3	2
Passive Search	4	4
Operation Test Passive	3	3
Passive Search Lab	5	3
Passive Track	3	3
BTR Display	2	2
Emergency Ops	1	1
Passive Track Lab	5	4
Active Localization	3	3
Active Track	1	1
Operational Test Active	2	2
Active Lab	10	8
MRC's and Emergency Ops	10	7
Passive Receiver Block	4	4
Active Receiver Block	4	3
Systems Programming Block	4	3
Transmission Block	3	2
CMS	8	6
Introduction AADD	1	1
AADD Software	2	1
AADD Hardware	2	1
AADD Op. Controls and Indicators	3	3

TABLE 8. SUBSURFACE CORE TRAINING REDUCTION (Continued)

Phase VII (continued)	Periods 19 Week	10 Week
AADD Mode Analysis and Display	3	3
AADD Lab	4	3
BQA-3	11	0
SAQ-GMT	7	7
Phase VII Exam and Review	5	3
Phase VII Subtotal	121	88
Phase VIII		
BQR-7C	16	0
BQQ-3 BV/BSM	13	0
SRGT/SAQ	5	0
GMT	2	0
Phase Exam and Review	3	0
Phase VIII Subtotal	39	0
Physical Analysis Phase		
Speed Translation	36	28
Combined Physical Analysis Practice	44	44
Physical Analysis Exam and Review	19	6
SRGT/SAQ	15	10
GMT	6	4
Physical Analysis Phase Subtotal	120	92

TABLE 8. SUBSURFACE CORE TRAINING REDUCTION
(Concluded)

Operational Trainer Phase	Periods 19 Week	Periods 10 Week
Sub F/C Organization	1	1
Relationship of Angles, True and Relative	2	2
Maneuvering Board	4	4
Bearing Rate Computer	1	1
Coffee Plot	1	1
Time Bearing Plot	2	2
Lynch Plot	6	6
3 Tip Plot	3	3
Watchstanding Responsibilities	3	3
Sonar Search Procedures	2	2
Tape Recording Procedures	1	1
Sonar Log	1	1
Reporting Procedures	1	1
Intro to Sonar Operational Trainer	2	2
Sub Operational Trainer	86	56
Fill Out FSS Student Critique Forms	3	3
Trainer Practical Exam	10	10
Final Exam and Review	3	3
Final SRGT Exam	1	1
Field Day and Graduation	11	11
SRGT/SAQ	19	14
GMT	8	6
Trainer Phase Subtotal	171	134
Grand Total	757	408

Representative Training Schedules

The alternative training schedules described below are proposed for consideration and are subject to revision. Our main purpose in presenting these schedules is to show the kind of variables which affect scheduling. Furthermore, in developing training proficiency evaluation plans, we need training schedule estimates. Final versions of alternate schedules cannot be prepared until the GenSOT course material has been developed.

As a general model on which we can base alternate training schedules, we have used primarily the Surface Sonar Technician training schedule at the "A-1" level. The main variables considered are:

- Four-year vs. six-year obligors
- NEOCS Study's recommendations
- The role of on-the-job training
- The impact of GenSOT

Our objective was to represent these variables in as few alternative schedules as possible while still allowing meaningful evaluation experiments to be performed at a later time.

There is some ASO training which could be general. This general training would occur early in the training sequence. Training on specific sonar systems would still be required, but this training would follow generalized training. Stated in other terms, we have placed generalized ASO training at the "A-1" school level. Our immediate concern beyond the "A-1" level is only

with specific system training. Basic E&E, "A-2" and "C" level courses are assumed to be essentially unchanged. The potential benefit from the introduction of GenSOT at the "A-1" level is that students would be better prepared for the higher level courses and better able to preserve their basic sonar operator skills during the time they spend in courses beyond the "A-1" level.

In the descriptions which follow, alternate schedules I and II do not include GenSOT. GenSOT is represented in alternate schedules III and IV.

Alternate Schedule I--Alternate I is the "A-1" training for surface sonar technician Class A. This training consists of six weeks of core phase followed by three to five weeks of operator basic training on specific systems such as MK114 or MK111 Underwater Fire Control, SQS-26 CX, AXR, or BX, SQS-23 TRAM/MIP/LORA or PAIR, or SQS-35/V. Following this 9 to 11 weeks of "A-1" training, the student is assigned to sea duty and OJT. This training sequence is typical for four-year obligors. The "A-1" level training for the six-year obligor is identical. However, following "A-1" training, the six-year obligor receives, instead of sea duty, seven weeks of Basic E&E, 14 weeks of "A-2" training, and 4 to 27 weeks in one or more "C" course and is then assigned to sea duty. Thus, our Alternate Schedule I represents current "A-1" level training for both four- and six-year obligors.

Alternate Schedule II--Schedule II essentially represents the NEOCS study's recommendation (Recommendation No. 6). The three-year obligor receives seven weeks of sensor indoctrination training and is then assigned to sea duty. This training is generalized and heavy reliance is placed on OJT.

(OJT would be represented during GenSOT evaluation by specific system trainers.)

Alternate Schedule III--This alternate schedule incorporates GenSOT into a 10-week "A-1" course which is followed by specific system training. Besides the introduction of GenSOT, this alternate is distinguished from Alternate I by its lack of training on a specific sonar system during "A-1." In Alternate III the training is analogous to the six weeks of Core Phase training of Alternate I. The implication is that at least the early part of specific system training would require changes to accommodate the introduction of GenSOT.

Alternate Schedule IV--The final alternate again incorporates GenSOT into a Core Phase analog but only of seven weeks duration. Alternate IV would require the same modification to early specific system training required in Alternate III.

In summary, the alternate schedules deal with the "A-1" level of training in either seven or ten weeks. One alternate of each duration uses GenSOT. For the GenSOT alternatives, changes in the early part of specific system training were assumed. A consideration of the comparison of these alternate schedules is contained in the discussion of proficiency evaluation.

SECTION VII

EVALUATION PLANS

INTRODUCTION

In our discussion of representative training schedules little emphasis was placed on the role of on-the-job training (OJT) or the interaction between GenSOT and OJT. In the specific system ASO training which is currently used, the role of OJT is primarily to maintain and reinforce skill and knowledge which was acquired in school. For generalized ASO training, the role of OJT could be of more significance. OJT would not only serve to maintain knowledge and skill, but it would provide the opportunity for familiarization with the knob and dial and special features of the specific system.

THE ROLE OF ON-THE-JOB TRAINING

The ability to train sonar operators through on-the-job training (OJT) represents a significant training resource. The efficiency with which this resource is used is dependent in part on how well the shore-based training prepares the student for OJT as well as the ability of the fleet to train the apprentice sonar operator while both instructor and student are engaged in actual sonar operation. One of the obvious drawbacks to OJT is that, while the ship is at sea, the sonar systems must be used to accomplish the primary mission objective. This means that both sonar equipment and experienced sonar personnel cannot be devoted primarily to training the inexperienced sonar operator.

Relatively recent changes, however, have tended to keep a larger part of the fleet in port. The implication for sonar operator training is that more sonar equipment and more experienced sonar personnel are available for training purposes at little additional cost. One of our contentions for generalized ASO training is that it has the potential for providing better Core Phase training. Better, in this sense, refers to the emphasis in generalized training on providing a solid understanding of concepts, functions, and functional relationships. In our view, these are the difficult areas for the student to grasp. In comparison, the knob and dial differences across specific sonar systems represent easier learning problems. Certain features of specific sonar systems, however, require an extension of the concepts and functional relationships presented in a generalized Core Phase of training, e.g., sensor deployment in the SQS-35/V and use of the mast mounted sensors in the BQR-19. Furthermore, the opportunity for drilling on sonar equipment to cement the student's recently acquired skills and knowledge in the shipboard environment is potentially available during pier-side OJT. Additionally, OJT must fill the need for maintaining the skills of the relatively experienced sonar operators.

A final point in stressing the need for intensive OJT is the potential impact of the NEOCS study's recommendation. If 90 percent of first enlistments are for three years as suggested in the NEOCS study, and if "A-1" level training is greatly abbreviated yet covers a wide range of material, then the ability of the student to actually operate a sonar system would be minimal. If OJT does not supplant this training deficiency, then in time the majority of sonar operators would be of doubtful quality in an operational situation.

We believe that these considerations strongly suggest a need for capitalizing on the opportunities afforded by pierside OJT.

Pierside OJT could be used effectively for:

- General knowledge and skills related to specific sonar systems,
- Practice on all aspects of the student's recently acquired sonar knowledge and skill, and
- Classification training.

Greatly disproportionate amounts of time are required for classification training. To accurately classify sonar signals, the operator must not only acquire the specific information related to classification, but he must also have a thorough understanding of basic sonar system operational principles which allow him to configure the sonar system for optimal presentation of the signals. Pierside OJT might provide the resources for the bulk of system specific classification training, thus allowing "A" school proper to devote more time for fulfilling knowledge and general skill training requirements.

However, the operational sonar systems in the fleet are not configured to provide intensive pierside OJT. These systems would require additional and/or modified equipment and other course material to provide intensive OJT. There would also be the obvious requirements for experienced sonar operators to serve as instructors and for coordination between "A" school and pierside OJT schedules and curricula.

To some extent the onboard equipment would determine the level of training which could be accomplished during pierside OJT. However, software availability would be the most significant determinant of the depth and scope of pierside OJT. We can suggest three levels of OJT which all include classification training. In generic terms there would be three subsystems which would apply to any of the three levels of training. The major subsystem is the specific sonar system which would be driven by a stimulator containing the interface between stimulator and sonar system and the interface between stimulator and the third subsystem, the simulator. For the least flexible level of OJT, the simulator would merely consist of a tape recorder operating in playback and a library of sonar signal tapes with appropriate descriptions of the circumstances under which the tapes were recorded. The sonar system would be configured to correspond to the recording conditions and the recorded signals would be presented on the appropriate system display. The only controls which could be manipulated would be for adjusting signal gain and display intensity, contrast, etc.

The intermediate level system would add problem solving and feedback features to the least flexible system. It would depend on the same tape library. However, the conditions under which the taped signals were recorded would be presented to the student as the "given" in a problem. The student would be required to configure the sonar system with respect to the information in the "given." (We assume the tapes were made with an optimally configured system.) The student would receive simple yes/no feedback through the system. An instructor would be available for coaching help. Once the desired configuration was achieved, the taped signals would be displayed and again only trivial gain and display control adjustments could be made.

The most flexible system would require a math model and computer. The models would be those which are under development at Naval Underwater Systems Center (NUSC). This system would permit complete or nearly complete sonar system control flexibility. In other respects it would resemble the intermediate level system. The roles for the equipment would change. For the simpler two systems, the simulator would be the tape library and the stimulator the tape recorder. For the most flexible system, the simulator would be the math model(s) and the computer system and the stimulator would contain any required signal conditioning electronics.

The necessary math models for the most flexible system are not now available. However, we have presented a use for this material in the context of pierside OJT to show its potential impact on OJT per se and on OJT as an integral part of a generalized ASO training program. Our limited conclusion from this examination of OJT is that the importance and effectiveness of OJT, especially for GenSOT, could be increased at little additional cost. That is, some training that is currently done in the expensive "A" School environment could be transferred to a pierside OJT, a resource which exists in nearly completed form today. A plan which includes an evaluation of this concept but with no requirement for actual OJT is shown in the following section.

PROFICIENCY EVALUATION

Introduction

The main objective of proficiency evaluation is to compare the efficiency and effectiveness of GenSOT with current training methods. Making this comparison in a valid way is not an easy task. There are many realistic constraints which preclude the use of a brute force experimental approach.

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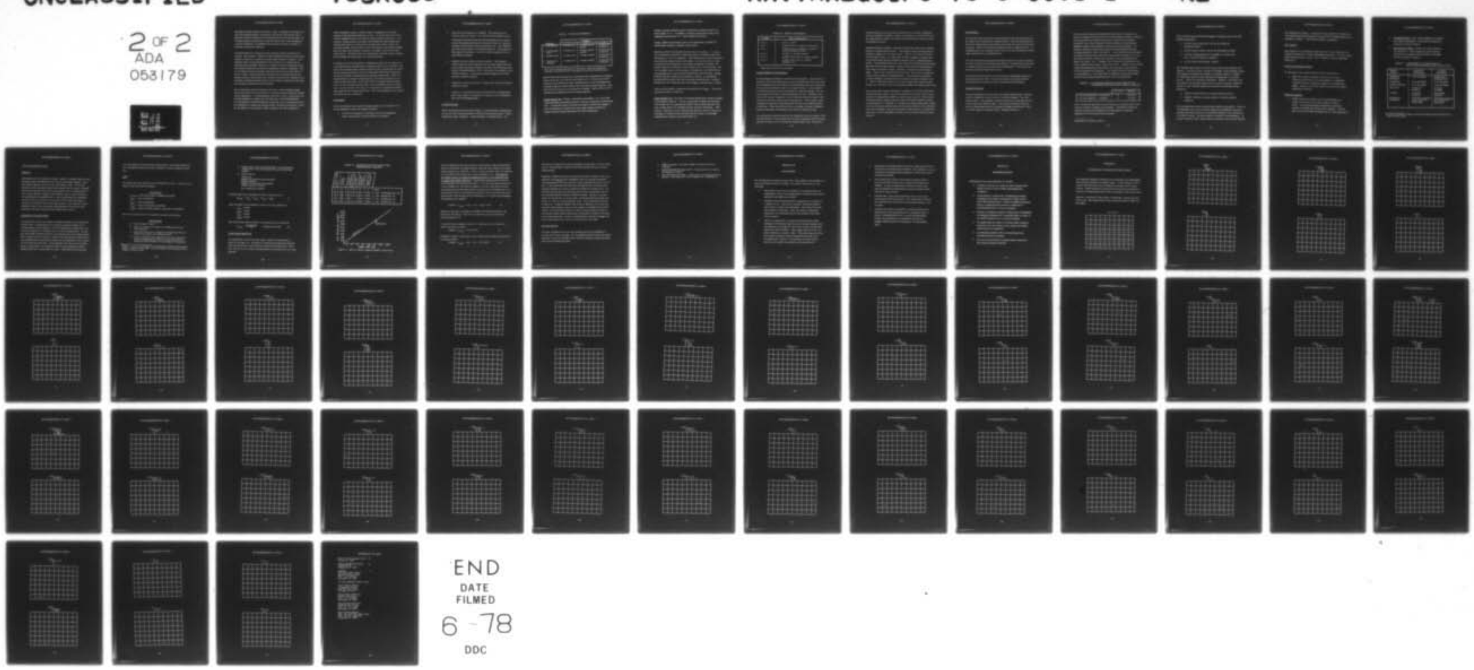

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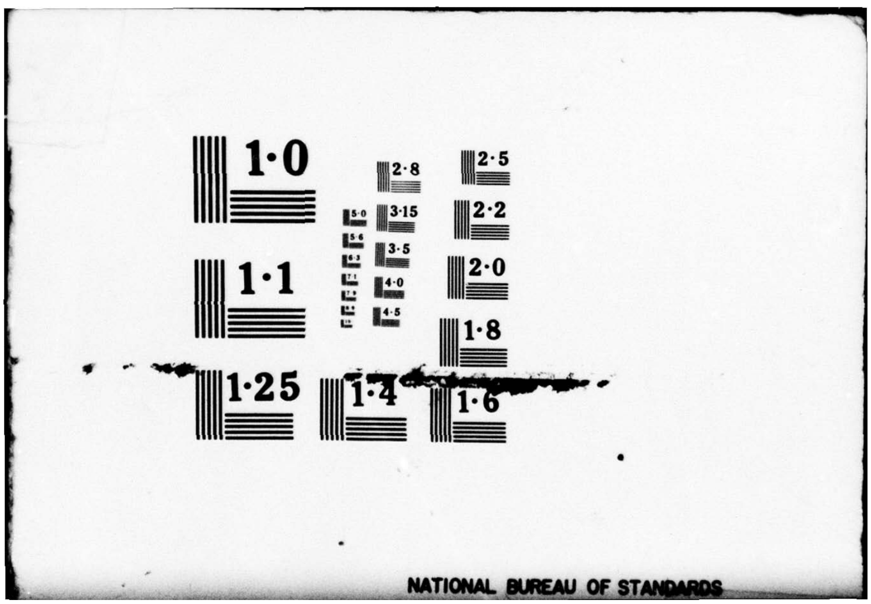
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2·2
5·6
3·5
1·1
2·0
4·0
4·5
1·8
1·25
1·4
1·6
NATIONAL BUREAU OF STANDARDS

Examples of these constraints are time, money, disruption of training schedules and training facilities, interference with career advancement, and, in general, excessive demands on the administration of naval ASO training. The evaluation plans presented below, while not entirely free from infringement on these constraints, accomplishes their purpose with what we believe is a minimum of constraint violation.

Evaluation plans were considered which would not conflict with these constraints. For example, a relatively simple experiment could be devised which could be conducted in a laboratory using college students as subjects. Sonar operator tasks could be generalized to tasks which are in common use in experimental psychology. However, the product of such an experiment would not satisfy the objective and would be completely lacking in credibility. That is, the relative merits of GenSOT would not be known in any practically useful way. Thus, we determined that the proficiency evaluation must be adequately realistic, using actual sonar students and instructors, realistic course materials, a prototype GenSOT device, and a realistic environment containing the customary distractions and motivations.

This environment could be achieved in two ways. The seemingly straightfoward way would be to use the facilities at the ASO school, adding the GenSOT related equipments. A second approach would be to create a small scale ASO training capability at another Navy location such as NAVTRAEQUIPCEN. For the purpose of GenSOT proficiency evaluation, the second approach would be satisfactory as long as the training and the associated environment created for the effort are very similar to those existing at the ASO training site.

Beside inadequate realism, another danger in designing the evaluation program is the unwitting introduction of bias. It is clear that experiments could be designed in such a way that the outcome could be predicted. For example, if some students were given conventional and others generalized training and if both were tested on the specific sonar system used in conventional training, then the results would clearly favor conventional training. While the bias in this example is obvious, the danger is from much more subtle biases. We believe that the incorporation of specific system training into the design described below will avoid this problem.

In addition to the overall problem of designing an experiment to achieve the stated objective for the proficiency evaluation program, and in addition to the problems of working within realistic constraints and avoiding bias, the experimental design must provide a set of comparisons which allows isolation of the effect of GenSOT, uncontaminated by possible interactions. Ideally, the design fulfills its purpose by requiring only a few elements which are to be compared with each other. In the first of the two designs discussed below, there are four training sequences which can be compared in only six unique ways. As we will show, each of the six comparisons resulting from this design yields directly relevant information. The second design is more compact and yields only one comparison.

Assumptions

Before proceeding to the evaluation designs proper, it is necessary to list the assumptions on which our designs are based:

1. A GenSOT prototypical or brassboard device and supporting course materials (as described above) are available.

2. Instructors and students are available. The instructors are trained to give the current "A-1" course and the GenSOT course. The students would be drawn from the ASO pipeline and assigned to the evaluation groups based on test scores which are currently available and the scores from one additional test. The additional test would relate only to the evaluation program. Participation in this program could delay a student's eventual assignment to sea duty following training.

3. Adequate school facilities would be available. This program would require the usual administrative and other support functions such as those currently available at the Fleet ASW Training Center, Pacific (FLEASWTRACEN, PAC). Classroom and laboratory space would be required. Conventional training equipment and course materials would be required.

4. Permission to give special tests relating to the evaluation program would be required.

5. In general, successful execution of the proficiency evaluation program would require coordination and support of the FLEASWTRA, PAC and NAVTRAEQUIPCEN.

Evaluation Design

Before discussing the details of the designs, it will be helpful to present and discuss the four training schedules on which the evaluation is based. Table 9 summarizes these schedules. Column III refers to simulated OJT. In a

TABLE 9. EVALUATION DESIGNS

DESIGNS	PHASES I	II	III
1. Conventional	6 weeks core	4 weeks specific system	3 weeks OJT (simulated)
2. Conventional/ OJT*	6 weeks core	4 weeks specific system	3 weeks OJT* (simulated)
3. GenSOT/OJT*	6 weeks core	4 weeks GenSOT	3 weeks OJT* (simulated)
4. Short Core/ GenSOT	3 weeks core	4 weeks GenSOT	3 weeks OJT* (simulated)

*OJT is the modified dockside OJT simulation, while OJT without an asterisk is conventional OJT (simulated) of only three weeks duration.

general sense this training uses conventional sonar equipment in an approximation of the way it is used on board ship for OJT. Pierside OJT (OJT*) would also use conventional sonar equipment but in a way that emphasizes training on specific system knobs, dials and special system features. Both OJT and OJT* would stress classification training. Neither OJT nor OJT* requires the development of new training equipment.

Design Number One--Design 1 represents conventional "A-1" level ASO training followed immediately by three weeks of a simulation of conventional OJT. The specific system on which the student is trained for Designs 1 and 2 during Phase II should be the same sonar system on which the student receives training during OJT and OJT* simulations.

Design 2 provides additional data on conventional training (specific systems) during "A-1". In addition, it permits comparisons based on the coupling of conventional "A-1" with modified OJT (OJT*).

Design 3 differs from Design 2 only by the substitution of GenSOT for conventional training on a specific sonar system.

Schedule 4 differs from Design 3 by the reduced core phase. The reduction is achieved by deleting or shortening certain maintenance topics and discussions of auxilary equipment. This schedule will require moderately accelerated learning during the core phase. In a non-exact way it could provide a partial assessment of the amount of learning, retention, and transfer that can be achieved in seven weeks of "A-1" level training. The use of GenSOT allows a loose analogy to be made with the NEOCS study's recommendation for abbreviated and generalized initial training. Design 4 differs from that study's recommendation, however, by specifically providing ASO training rather than only sensor indoctrination. Designs 1 through 3 are of 13 weeks duration, while Design 4 requires only 10 weeks.

There are six possible comparisons among the four designs. These comparisons are shown in Table 10.

<u>Design Number Two</u>--The second evaluation design option compares Design 1 with Design 2 (Table 9). That is, conventional training with simulated conventional OJT is compared with GenSOT with simulated pierside OJT. Thus, design number two contains only the essential comparison. This, however, represents a low in experimental efficiency since the number of conditions is reduced by only one half while the number of meaningful comparisons is reduced to one sixth (Table 10).

TABLE 10. DESIGN COMPARISONS

Designs	Main Comparisons
2 vs. 1	OJT* vs. OJT[1]
3 vs. 1	GenSOT/OJT* vs. specific system/OJT
4 vs. 1	GenSOT/short core/OJT* vs. specific system/standard core/OJT
3 vs. 2	GenSOT vs. specific system
4 vs. 2	GenSOT/short core vs. specific system
4 vs. 3	GenSOT/short core vs. GenSOT standard core

[1] Both OJT and OJT* are simulated.

Testing Schedule and Comparisons

For both designs schedules are divided into three phases. Test scores are used prior to the first phase since we can assume that the usual test scores of the candidates (selected students) will be somewhat skewed in comparison to the normally distributed scores of all naval recruits. A short aptitude test will be used which measures aptitude for technical training. This test can be expected to yield a normal distribution of scores. Students will be selected for random assignment to each of the four schedules based on their closeness to the mean score from the aptitude test. These students could reasonably be expected to fall within plus or minus one standard deviation of that mean. This tactic will be used in an attempt to equate intelligence, technical knowledge, and aptitude across the four schedule groups.

The second test session would follow the completion of the core phase. This test will provide a measure which will be used in comparing the three weeks with the six weeks of core training (for design number one). Since there

would be only one core curriculum regardless of the student's subsequent platform assignment (airborne, surface, or subsurface), there will be a further opportunity to compare the single, revised curriculum with each of the conventional curricula.

Following Phase II training, a third test will be given either on the GenSOT device or a specific sonar system. For specific testing following Phase II training, a single new test must be used. That is, if a test were devised for the GenSOT device, we could expect students assigned to Design 3 and 4 to do better than students assigned to specific system training (Designs 1 and 2). If conventional tests were used, the reverse situation would pertain. Basically this test will provide a measure of the student's understanding of basic sonar operational concepts, functions, and functional interrelationships. Thus, by the required nature of the test, there may be a slight bias in favor of the students receiving GenSOT. This test will also provide a measure allowing a comparison between students assigned to Design 3 and 4. That is, these test scores can be used to compare the relative impact of three vs. six weeks of core on subsequent GenSOT (for design number one).

The last test will be given following the completion of the three-week simulated OJT or OJT* course. The scores from this test will be used to assess transfer of training from GenSOT to specific sonar systems. These scores will also be used to compare the OJT with OJT* following specific system training during "A-1" (Design 1 vs. Design 2 for design number one). Lastly, these scores will provide the basis for an overall evaluation of the effectiveness of the schedules. This final test will be comprehensive, covering both basic sonar-related knowledge and skills on the operation of specific sonar systems.

Test Structure

The structure of the four tests just mentioned has been described earlier in this report and we only need to summarize here. The first testing will use the scores already found in personnel records plus the scores from the aptitude tests. These scores will be combined to form a single test score. A straightforward way to combine these scores is to first normalize to percentages and then form an unweighted mean.

The second and third tests following Phases II and III will closely resemble the tests currently used following these phases. Concepts and function will be emphasized and specific equipment de-emphasized. Both written and laboratory practical exams will be used.

The final test will also have a written portion for knowledge testing and a laboratory practical exam. All practical exams will employ problem solving based on scenarios similar to those used during training.

Design Formalisms

We have already given an overview of the experimental design. Students would be assigned at random to each of the four schedules. Four tests would be given. The dependent measures would be accuracy (percent correct) and the tests would be timed. The amount of material in the test would be large enough so that only superior students could finish. Thus, in a sense, speed of response is also a dependent measure.

The size of the evaluation is determined by the number of subjects, the number of platforms and the number of training designs (defined in Table 9). If we assume that six subjects per group are required for statistical reliability, then a large evaluation could be defined by considering two platforms (surface and subsurface) and all four training designs. The smallest evaluation would consist of only the surface platform and two training schedules (1, and 3, in Table 9). If the GenSOT device can handle six subjects simultaneously and if the training cycles overlap (e.g., when the first six subjects complete the core phase, the second group of six begins core phase, etc.). Designs 3 and 4 conducted in sequence for the large evaluation would require a total of 34 weeks. Designs 1 and 2 could be conducted simultaneously with Design 3 and 4 and thus not increase the 34 week duration of the evaluation. The small evaluation would require 13 weeks (Table 11). We assume that the different versions of OJT (OJT and OJT* for the different platforms) can occur simultaneously.

TABLE 11. ALTERNATIVE SIZES AND DURATIONS OF THE EVALUATION FOR THE GenSOT SYSTEM APPROACH

	No. of S's	Duration
6 S's and 2 platforms, 4 schedules*	48	34 weeks
6 S's and 1 platform, 2 schedules	36	22 weeks

Other versions of experiment size and duration are possible based on the number of subjects, platform and schedules. Reducing the number of subjects decreases the likelihood of demonstrating the statistical significance of differences among the groups.

*Schedules are defined in Table 9.

There are four main concerns which apply to training in general and ASO training in particular.

1. Are the correct (relevant to the end use) skills and knowledge trained ?
2. Do the trainees actually acquire the knowledge and skills?
3. Does the training generalize or transfer to related areas (e.g., one sonar system to another)?
4. Are the skills and knowledge retained ?

Our evaluation plan assumes the first concern and directly addresses the concern. The third concern, transfer of training, is only partially treated. The transfer of training from GenSOT to a specific system is evaluated by comparision with the results obtained by training only on a specific system. This is the important comparison. However, since ASO's who are trained on one specific system may be required to operate a different system, a more thorough design would compare the following training sequences:

- Train on specific system A, operate specific system B.
- GenSOT, followed by specific system A, and then specific system B.

This missing feature of the evaluation plan could be incorporated. However, the additional cost in time and money might not be justified by the gain in additional information which is not absolutely essential to the evaluation of the GenSOT concept. The fourth concern, retention, is not evaluated. To evaluate this point would require follow-up testing at some interval following

the completion of training. It would also require that the new ASO's have very similar experience during the interval between training completion and testing for retention. This would be difficult to guarantee.

Data Analysis

Data analysis for the evaluation experiment can be very simple since the design of the experiment avoids confounding interactions. For the comparisons discussed earlier, only a t-test is required to test for significant differences.

Summary of Evaluation Options

To summarize, the evaluation options we have discussed are:

- OJT--OJT could be simulated at any of three levels to represent pierside OJT or it could simply be a continuation of specific system training with emphasis on classification skills. However, some form of OJT is required for GenSOT proficiency evaluation.

Evaluation Facilities

- GenSOT evaluation could be done at the ASO School or a small scale version of this school could be created at NTEC. A general psychological laboratory experiment would be of doubtful effectiveness and credibility. Table 12 lists several of the differentiating factors in these approaches.

- Training Schedules--Four training designs were defined; two of them used GenSOT. Six relevant comparisons result from the four schedules.

- Experimental Designs--A large and a small evaluation were described. These designs measured learning effectiveness, partially measured transfer of training, but did not measure retention.

TABLE 12. COMPARISON OF LABORATORY AND FIELD APPROACHES FOR GenSOT EVALUATION

Program Factors	Laboratory Environment	A-School Environment
Program of Instruction	To be Developed	Modification to Existing Course
Courseware	To be Developed	To be Developed
GenSOT Prototype	To be Developed	To be Developed
Instructors	Contractor Provided	A-School Provided
Trainees	Contractor Procured	Instructional Pipeline*
Performance Evaluation	Objectively Measured by Pre/Post Test Differentiate	Objectively Measured by Pre/Post Test Differential

*Process of evaluation might necessitate increasing school residency by as much as seven weeks.

COST EVALUATION MODEL

Objective

Our objective for this task was to select, modify, or develop a plan for comparing the costs of GenSOT with the costs of conventional training. There were three important criteria for the cost model to meet: 1) The cost elements in the model plan should clearly expose both the impact of GenSOT and the cost elements which are the significant drivers in determining the cost of sonar operator training; 2) Information about the cost elements in the model should be available; that is, real cost data should be obtainable for each of the cost elements in the model; 3) The model should permit comparison of GenSOT with conventional training. Less important considerations are ease of use and linear relationship with main cost driving functions. The model described below meets these criteria.

Application to Training Phases

To simplify and clarify the problem of comparing GenSOT with conventional training costs, the application of the model for particular phases in the training sequence was considered. The training sequence begins with classroom work and ends (or continues) with on-the-job training (OJT). We suggest that GenSOT would have direct cost implications for the training phases which require the use of trainers, indirect cost implications for OJT and for some phases which are primarily conducted in the classroom, and no impact for the early classroom work. In the example of the use of the cost model which is shown below, we considered only the training phases for which GenSOT would have a direct effect on costs. These phases are concerned

with the training of aural and visual target search, tracking and classification, equipment setup and procedure following, and basic equipment operation.

Model

The model itself was modified from a TECEP[10] cost model. The major cost factors in the model were as follows:

Cost Factors

C_{Total} = Total training cost in dollars per student

C_{Fac} = Cost of facilities

C_{Equ} = Cost of equipment

C_{Inm} = Cost of instructional materials

C_{SPS} = Costs for school supplies, personnel, and students

Each of the cost factors were composed of several cost elements:

Cost Elements

A = Course length in hours

B = Hours in a school year (taken to be 4000 hours for two-shift operation)

C = Yearly facilities cost in dollars per student area (ft^2) per student times yearly cost (dollars per ft^2)

D = Life cycle (years) cost (dollars) per life cycle (years) per student (considering the number of student positions per equipment which we take to be six students per equipment)

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[10] Braby, R. et al, "A Technique for Choosing Cost-Effective Instructional Media," TAEG Working Draft, Training Analysis and Evaluation Group, Orlando, Florida, 1974.

E = Yearly cost of instructional materials, including developmental costs, over the equipment life cycle (dollars per student)

F = Yearly cost of:

Instructors
Support and administrative personnel
Student supplies
Support and administration supplies
Student wages and benefits

(all in dollars per student)

Training costs can be expressed in terms of cost factors as

$$C_{Total} = C_{Fac} + C_{Equ} + C_{Inm} + C_{SPS} \quad (1)$$

Each cost factor can be defined in terms of its cost elements as

$$C_{Fac} = AC/B$$
$$C_{Equ} = AD/B$$
$$C_{Inm} = AE/B$$
$$C_{SPS} = AF/B$$

and total training costs in terms of cost elements can be defined as

$$C_{Total} = \frac{A(C+D+E+F)}{B} \quad \text{in dollars per student} \quad (2)$$

Sample Model Application

To demonstrate the use of the cost model, consider the data shown in Table 13 and Figure 14. The data for conventional training were obtained from several sources, some of them as much as three years old. Therefore, the cost of conventional training should be considered here as a rough estimate.

TABLE 13. ESTIMATED COSTS OF GenSOT AND CONVENTIONAL TRAINING

Course Length hours	Training hours/yr	Facilities $/student/ft^2	Life Cycle Cost $/student	Instructional Materials $/student/yr	Support Costs $/student/yr		
A	B	C	D	E	F	Total	
120	4000	600	700	18750	26367	1,393	Conventional Eq. (2)
120	4000	600	350	23500	26367	1,525	GenSOT Eq. (3)
120	4000	600	---	18750	26367	1,372	GenSOT Eq. (4)
120	4000	600	350	14063	26367	1,241	GenSOT Eq. (5)

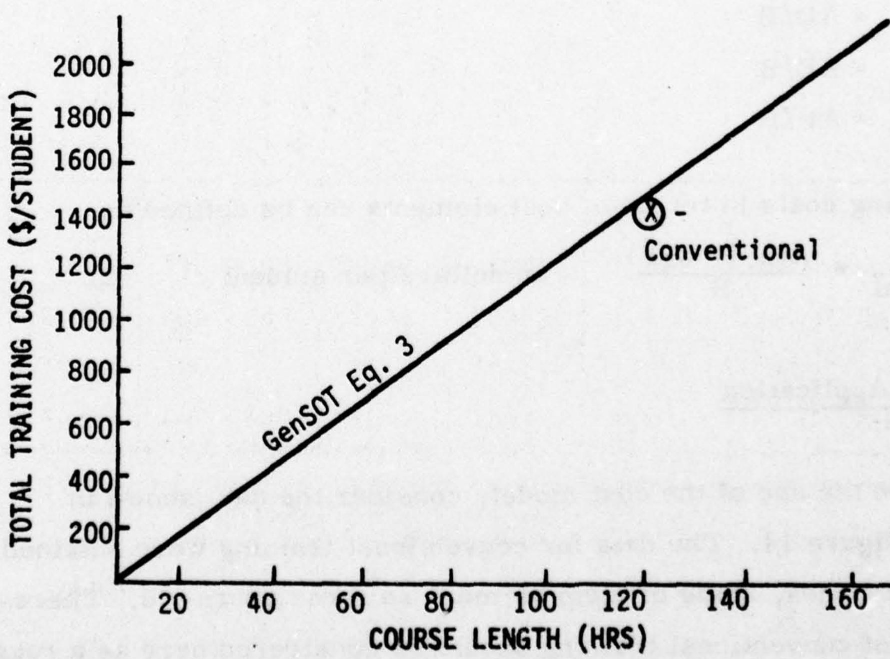


Figure 14. Effect of Course Length on GenSOT Course Cost

Since our purpose here is not to discuss actual costs but only to demonstrate the use of the model, our approximations need only show relative cost magnitudes among the cost elements. That is, yearly personnel costs, for example, are about forty times greater than yearly equipment costs. Our estimates for GenSOT costs are completely hypothetical; there are no empirical data to support our GenSOT estimates. Conventional training costs in terms of costs elements were defined in Equation 2. If we estimate that the equipment cost for GenSOT was one-half the equipment cost for conventional training (cost element D) and the instructional materials costs for GenSOT were 1.25 times greater than for conventional training due to increased software development costs (cost element E) and if elements A, C, F and B were unchanged, then GenSOT costs would be

$$\text{GenSOT},\ C_{\text{Total}} = A(C + .5D + 1.25E + F)/B \qquad (3)$$

Equation 3 was used to calculate the GenSOT cost estimates shown in the second row of Table 13. The first row shows the cost of conventional training [Equation (2)].

To show the lack of impact of element D, equipment cost, we have eliminated this factor as follows:

$$\text{GenSOT},\ C_{\text{Total}} = A(C+E+F)/B \qquad (4)$$

Showing the impact of reducing the cost of instructional material (element E), the equation reads:

$$\text{GenSOT},\ C_{\text{Total}} = A(C + .5D + .75E + F)/B \qquad (5)$$

To show the strong effect on cost of reducing course length, we have plotted cost vs. course length in Figure 14 and have indicated the cost of conventional training.

Inspection of Equation (2) and of the estimates shown in Table 13 shows that equipment costs per se have a negligible effect on training (eliminating training equipment entirely would only reduce training costs by $21 per student). These estimates also show that changing the cost of instructional material (element E) can have a significant impact on training costs. The difference between plus and minus 25 percent from conventional costs for instructional material amounts to $284 per student. However, the main impact on training cost is course length, operating primarily through cost element F, which is mostly personnel costs. This relationship is plotted in Figure 14. Using the GenSOT costs shown in Equation (3), we find that reducing course length by only one hour results in a savings of $12.50 per student. A course length reduction of about 10 hours (about 8 percent of conventional course length) would offset a 25 percent increase in the cost of instructional materials. These few examples were included to suggest the kinds of information which can be derived from the cost model.

Cost Data Sources

The final consideration for the cost evaluation plan is the availability of accurate and current cost data. Our investigations show that the cost breakdowns for current and relevant sonar technician training courses are available from the following sources:

- CNET Pensacola, "Cost (per student) for Sonar Technician Training"
- NAVTRAEQUIPCEN Report 10171, "Training Device Utilization and Application Report"
- NAVTRAEQUIPCEN Report, "Financial Accounting and Inventory Record," CDG Symbol 20, CNET Program No. DFAROQL115

SECTION VIII

CONCLUSIONS

The information and analyses of this year's work supported the feasibility of Generalized Sonar Operator Training. Our specific conclusions are the following:

- The GenSOT device must be designed for training functions and relationships and not for training aspects of specific sonar system operation at the knob and dial level.
- Computer Aided Instruction (CAI) is appropriate for inclusion in a GenSOT device. The level or amount of CAI which would be most effective is still to be determined. The level of CAI influences system architecture. Thus, two system architectural alternatives were presented based on the amount of CAI which will be required.
- There is an opportunity to increase the effectiveness of ASO training by elevating the importance of on-the-job training (OJT). The opportunity to modify the role of OJT directly and favorably affects the value of GenSOT. The changes required in OJT are neither difficult nor costly to effect. The major impact would be the transfer of specific system training from the fleet ASW Training Center, Pacific, to the portion of the fleet which is pierside and available for intensive and structured OJT.

- Core phase and GenSOT phase curriculum modifications would be required for the introduction of GenSOT. New subsurface, surface, and airborne curricula would be required as well as new course material for GenSOT.
- The introduction of Proteus will require extensive revision for airborne ASW training with or without the introduction of GenSOT. It was not practical at this time to directly evaluate the feasibility of generalized training for airborne ASO's who will be using Proteus.
- Course length, which affects personnel costs, is the major determinant of ASO training cost. The combination of GenSOT and intensified OJT could reduce course length and thus training costs.
- Continued development of GenSOT is totally dependent on the endorsement by and establishment of a coordinated effort of CNET, FLEASWTRACEN, PAC, and NAVTRAEQUIPCEN. If either the endorsement or cooperation elements are lacking, further pursuit of this program is of questionable value.

SECTION IX

RECOMMENDATIONS

Following are our recommendations for GenSOT:

- A survey of current user needs and future requirements should be made to insure GenSOT applicability and acceptance.
- A plan should be prepared for arranging the necessary coordination and support requirement of CNET and the Fleet ASW Training Center, Pacific in GenSOT implementation or a testbed capability should be established at NAVTRAEQUIPCEN for concept evaluation.
- Further investigations should be conducted for the feasibility of developing intensified OJT at pierside either as a part of the GenSOT program or as a separate program.
- The applicability of GenSOT for airborne ASO's should be determined once the Proteus system design and training requirements are established.
- A prototypical GenSOT device and supporting course materials should be developed.
- The cost and effectiveness evaluation plans described in this document should be effected.

APPENDIX A

MATRICES OF FUNCTIONAL INTERACTIONS

This appendix contains an indication of the functional interrelationships which must be included in a GenSOT device. In each matrix the "X's" indicate functions which must be designed to interact with the object function. Object functions are shown at the top of each matrix and are entered in the appropriate matrix square according to their code number.

Below is a "key matrix" which shows, numerically, the entry for each matrix cell. The numerical key refers to the code shown in Table 3 of this report.

INTERACTION MATRIX KEY

1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	1.10
1.11	1.12	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8
2.9	2.10	2.11	2.12A	2.12B	2.12C.1	2.12C.2	2.12C.3	2.12C.4	2.12D
2.12E	2.12F	2.13A	2.13.B	2.13.C	2.14.A	2.14.B	2.14.C	2.14.D	2.14.E
2.14.F	2.14.G	2.14.H	2.14.I	2.14.J	2.14.K	2.14.L	2.14.M	3.1.A	3.1.B
3.1.C	3.1.D	3.1.E	3.2.A	3.3.A	4.1.A	4.1.B	4.2.A	4.2.B	4.2.C
4.2.D	4.3.A	4.3.B	4.3.C	5.1	5.2	5.3	6.1		

1. TRANSMISSION
1 COVERAGE
1 ODT
2 RDT
3 BB+RDT OMNI
4 CZ+RDT OMNI

1.1	x	x	x	x	x	x	x	x	x
x	x	x	x	x	x	x	x	x	
x	x	x	x		x	x	x	x	
		x		x		x	x	x	x
	x	x					x		
			x		x	x	x		
x							x		

1. TRANSMISSION
2. FREQUENCY
5. 3.0 kHz
6. 4.5 kHz
7. 6.0 kHz

x	1.2			x	x		x	x	
		x		x		•			
x						x			

1. TRANSMISSION
   3. PULSE WIDTH
      8. 5 MSEC
      9. 30 MSEC
      10. 120 MSEC

X		1.3	X		X	X	X	X	
				X					

1. TRANSMISSION
   4. BANDWIDTH
      11. 0.2
      12. 6.0
      13. 25.0

		X	1.4		X				

1. TRANSMISSION
    5. POWER OUTPUT
        14. OFF
        15. 120 dB
        16. 130 dB
        17. 140 dB

X	X			1.5	X	X	X	X	
						X			
X									

1. TRANSMISSION
    6. TYPE
        18. CW
        19. FM

X	X			X	1.6	X		X	
						X			

1. TRANSMISSION
   7. PATH
      20. SURFACE DUCT
      21. BOTTOM BOUNCE
      22. CONVERGENCE ZONE
      23. DIRECT

X		X	X		X	1.7			X
						X			
X									
		X							

1. TRANSMISSION
   8. RANGE
      24. 1 kyd
      25. 5
      26. 25
      27. 50
      28. 100

X				X		X	1.8		X
X									
						X			

1. TRANSMISSION
9. ARRAY
29. SPHERICAL
30. CYLINDRICAL

X	X				X	X	X	1.9	X
						X			

1. TRANSMISSION
10. D/E ANGLE
31. +10° TO -40°

X				X		X	X		1.10
						X			
		X							

1. TRANSMISSION
   11. SECTOR CENTER
      32. 0° TO 360°

1.11									

1. TRANSMISSION
   12. SECTOR WIDTH
      33. 30°
      34. 70°
      35. 100°
      36. 150°
      37. 200°

	1.12								

2. RECEPTION
   1. FREQUENCY BAND
      38. 0 TO 100 Hz
      39. 100 Hz TO 1 kHz
      40. 1 kHz TO 2 kHz

2. RECEPTION
   2. BANDWIDTH
      41. 1000 Hz
      42. 2000 Hz
      43. 3000 Hz
      44. 4000 Hz
      45. 5000 Hz

			2.2						

2. RECEPTION
   3. SIGNAL PROCESSING
      46. OFF
      47. HETERODYNE

X					X	X			
				2.3					
					X				

2. RECEPTION
   4. BEAM WIDTH (PREFORMED BEAM)
      48. 5º
      49. 10º
      50. 15º

					2.4				

2. RECEPTION
5. ARRAY
51. SPHERICAL
52. CYLINDRICAL
53. LINEAR

						2.5			

2. RECEPTION
6. INTEGRATION TIME
54. OFF
55. STA
56. ITA
57. LTA

							2.6	x	
		x							

2. RECEPTION
   7. INTEGRATION TIME
      58. OFF THROUGH 10 MINUTES

							X	2.7	
		X							

2. RECEPTION
   8. BAND PASS FILTERS
      59. OFF
      60. 0-500 cps
      61. 0-2 kcps
      62. 0-5 kcps
      63. 0-10 kcps

				X		X			2.8

2. RECEPTION
   9. SOUND VELOCITY
      64. 4800 TO 5200 fps

X	X					X			
2.9									

2. RECEPTION
   10. CLIP CORRELATION
       65. ON
       66. OFF

2. RECEPTION
   11. LINEAR CORRELATION
      67. ON
      68. OFF

		2.11							

2. RECEPTION
   12. AUDIO
      A. TYPE
         69. ANALOG
         70. DIGITAL

			2.12.A						

2. RECEPTION
   12. AUDIO
      B. OUTPUT
         71. PHONES
         72. SPEAKER

				2.12.B					

2. RECEPTION
   12. AUDIO
      C. MODE
         1) LISTEN
            73. ON
            74. OFF

			X	X	2.12.C.1				X

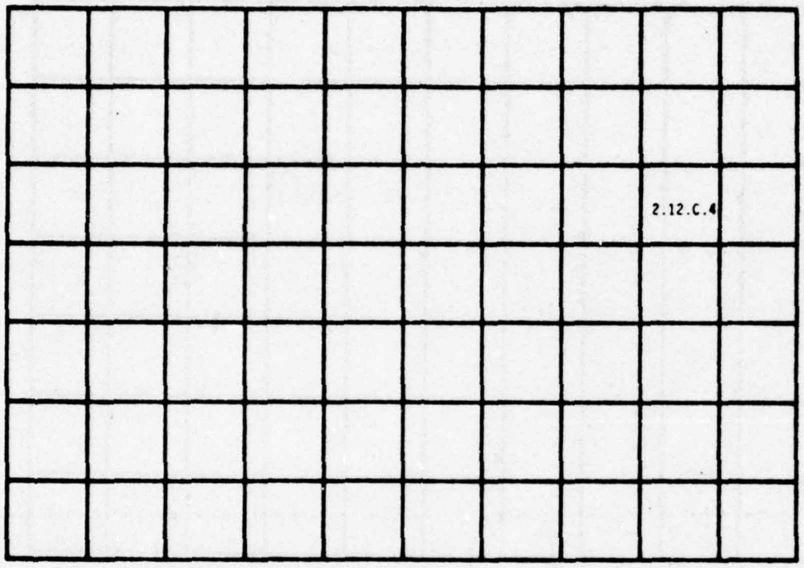
2. RECEPTION
   12. AUDIO
      C. MODE
         2) SUM/DIFFERENCE
            75. SUM
            76. DIFFERENCE

X									
					X	2.12.C.2			X

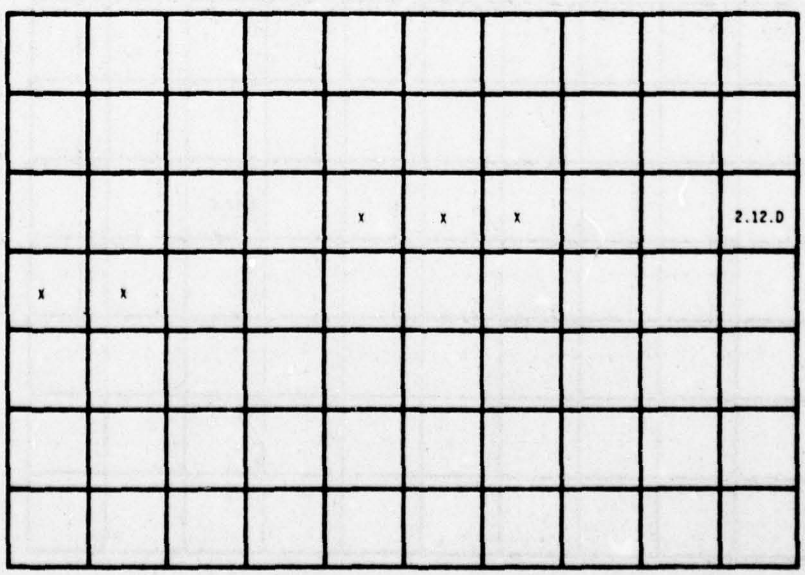
2. RECEPTION
   12. AUDIO
      C. MODE
         3) PREFORMED BEAM
            77. ON
            78. OFF

							2.12.C.3		

2. RECEPTION
12. AUDIO
C. MODE
4) CLASSIFICATION
79. ON
80. OFF



2. RECEPTION
12. AUDIO
D. GAIN



2. RECEPTION
   12. AUDIO
      E. AGC
         82. ON
         83. OFF

									X
2.12.E									

2. RECEPTION
   12. AUDIO
      F. TIME VARIED GAIN
         84 ON
         85. OFF

	2.12.F								

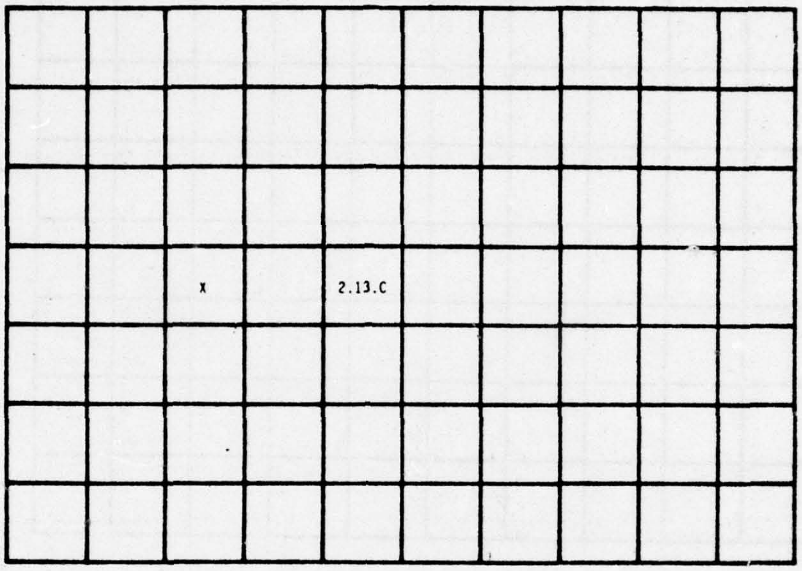
2. RECEPTION
13. VISUAL DISPLAY, CRT
A. FORMAT
86. A SCAN
87. B SCAN
88. PPI
89. SPECTRAL
90. BTR
91. SSI
92. DOPPLER

X						X			X
							X	X	
		2.13.A	X						
	X	X							

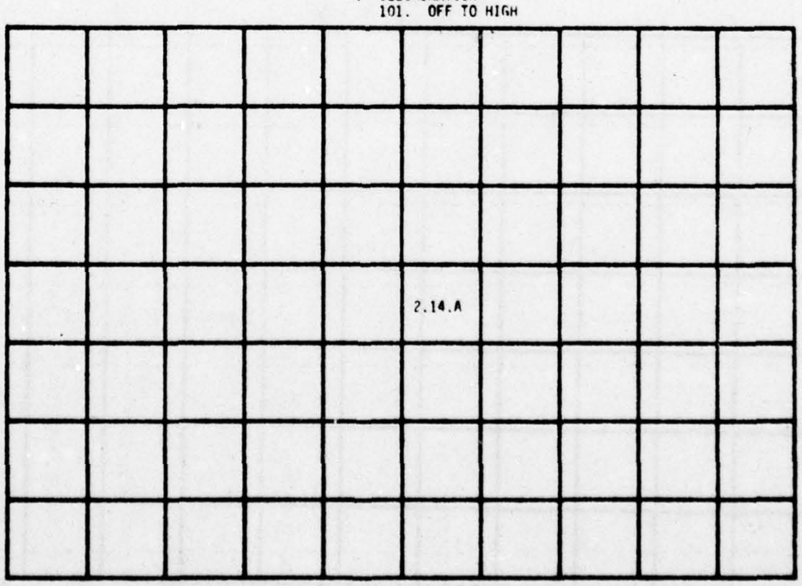
2. RECEPTION
13. VISUAL DISPLAY, CRT
B. DISPLAY CENTER
93. TCD-ON
94. TCD-OFF
95. SCD-ON
96. SCD-OFF

		X	2.13.B						

2. RECEPTION
13. VISUAL DISPLAY, CRT
C. CISPLAY CONTROLS
97. FOCUS
98. INTENSITY
99. CONTRAST
100. CURSOR INTENSITY



2. RECEPTION
14. VISUAL DISPLAY, CHART
A. ILLUMINATION
101. OFF TO HIGH



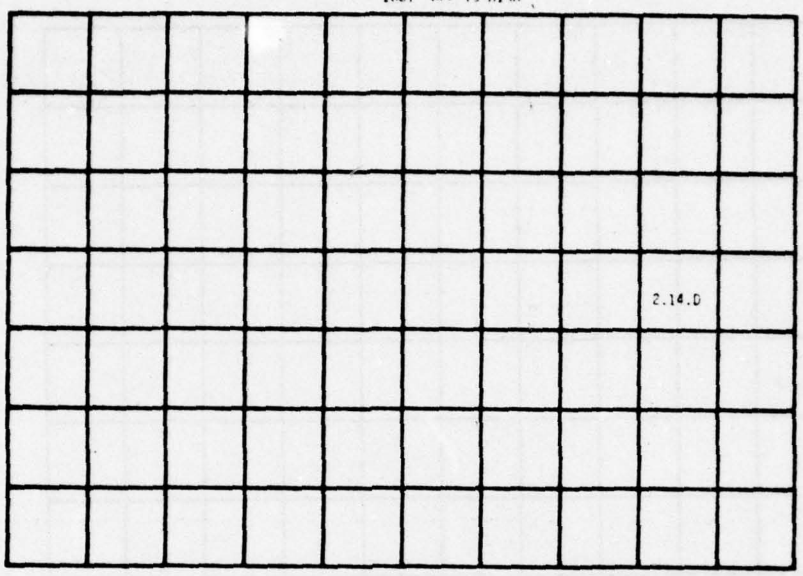
2. RECEPTION
14. VISUAL DISPLAY, CHART
B. ANTI-SATURATION
102. OFF
103. 1
104. 2
105. 3
106. 4

						2.14.B	X	X	X

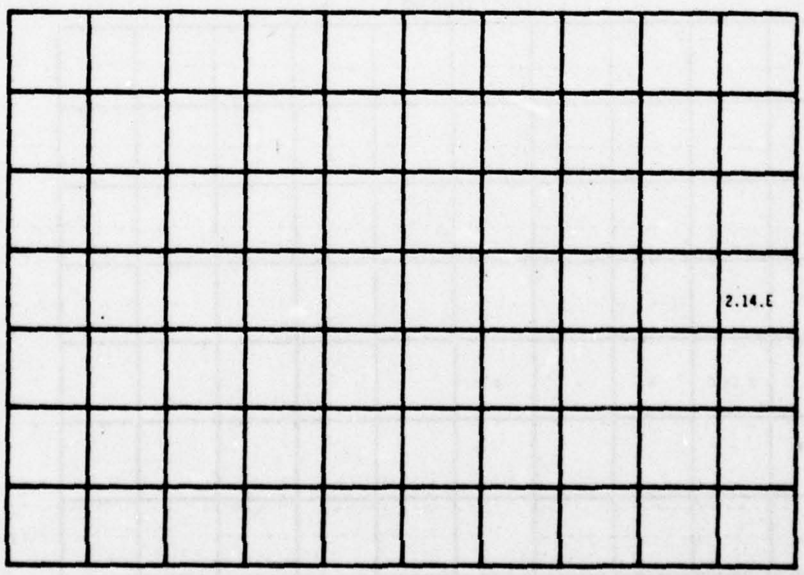
2. RECEPTION
14. VISUAL DISPLAY, CHART
C. CONTRAST
107. OFF TO HIGH

							2.14.C		X

2. RECEPTION
14. VISUAL DISPLAY, CHART
D. THRESHOLD
108. OFF TO HIGH



2. RECEPTION
14. VISUAL DISPLAYS, CHART
E. MARKING DENSITY
109. OFF TO HIGH



2. RECEPTION
14. VISUAL DISPLAYS, CHART
F. CURSOR
110. MARK
111. OFF

2.14.F									

2. RECEPTION
14. VISUAL DISPLAY, CHART
G. TBR/GRR
112. TBR
113. GRR

	2.14.G	X	X	X					

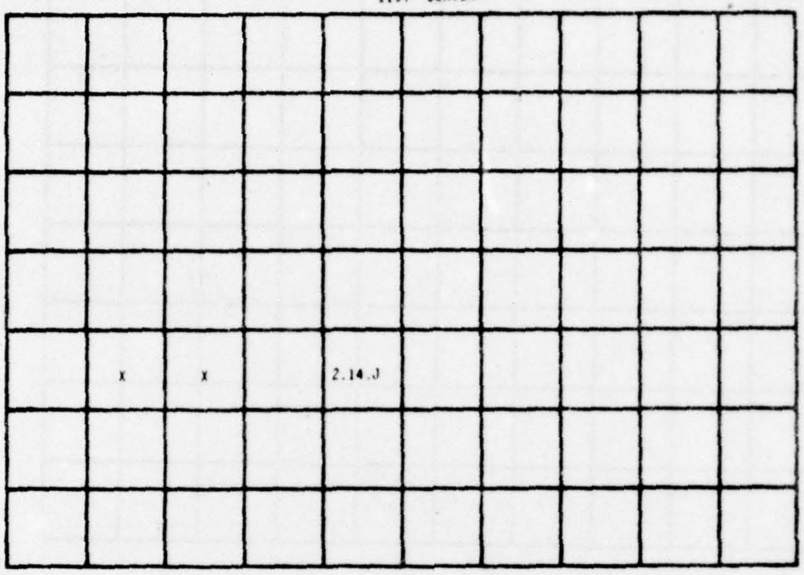
2. RECEPTION
14. VISUAL DISPLAY, CHART
H. STANDBY-ON
114. STBY
115. ON

	X	2.14.H	X	X					

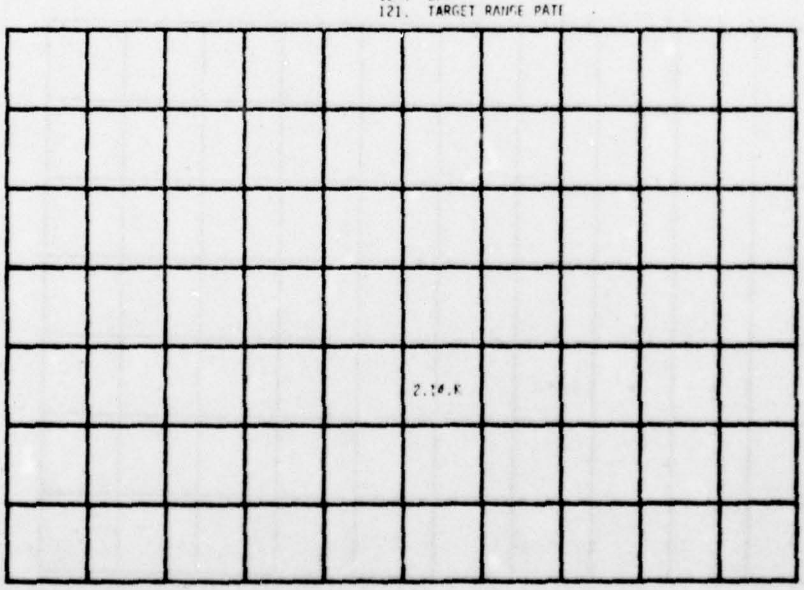
2. RECEPTION
14. VISUAL DISPLAY, CHART
I. TBR CENTER
116. 000°
117. 180°

	X	X	2.14.I						

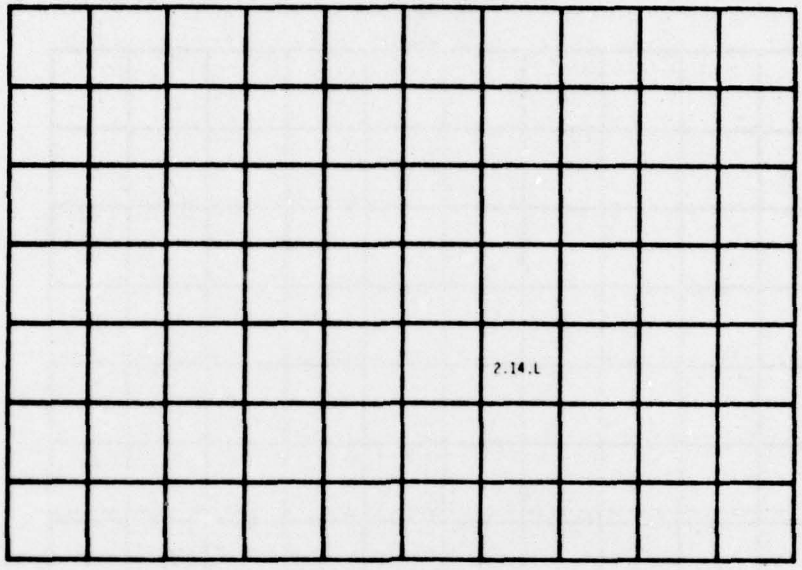
2. RECEPTION
   14. VISUAL DISPLAY, CHART
       J. GRR UPDATE
          118. UPDATE
          119. CENTER



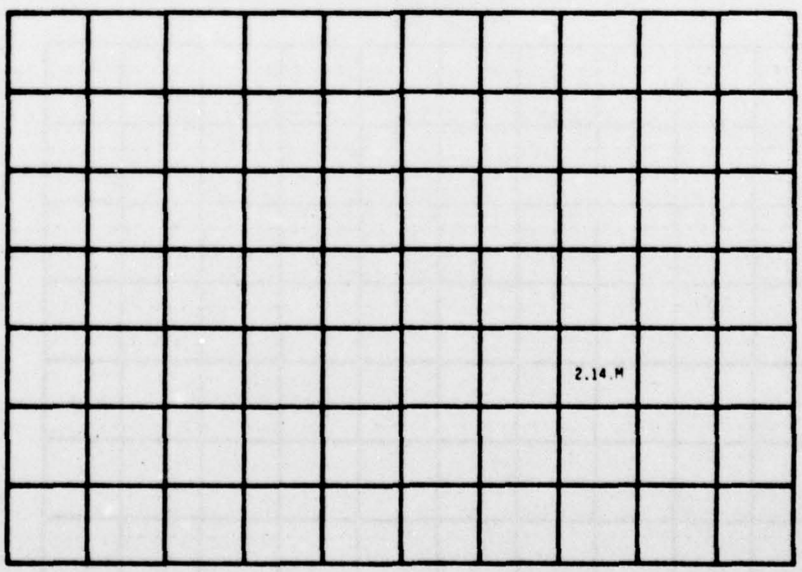
2. RECEPTION
   14. VISUAL DISPLAY, CHART
       K. TARGET RANGE RATE
          120. OFF
          121. TARGET RANGE RATE



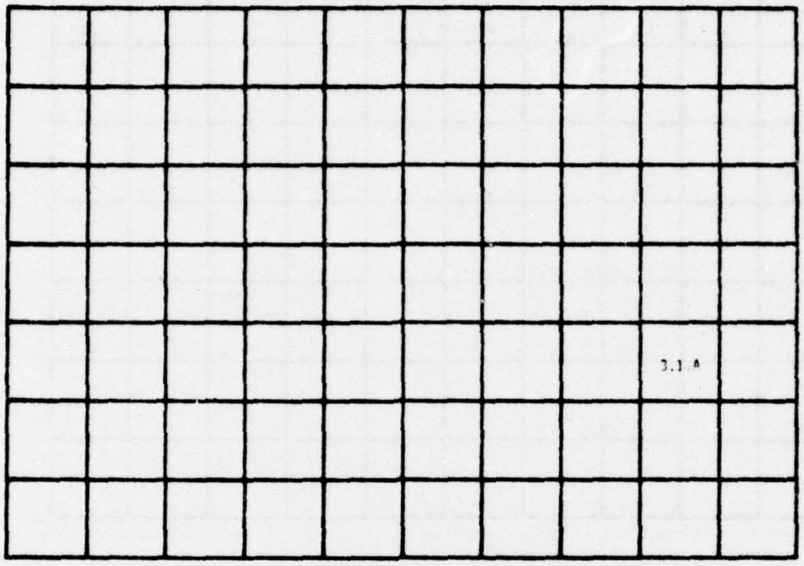
2. RECEPTION
   14. VISUAL DISPLAY, CHART
       L. TOTAL RANGE RATE
          122. OFF
          123. TOTAL RANGE RATE



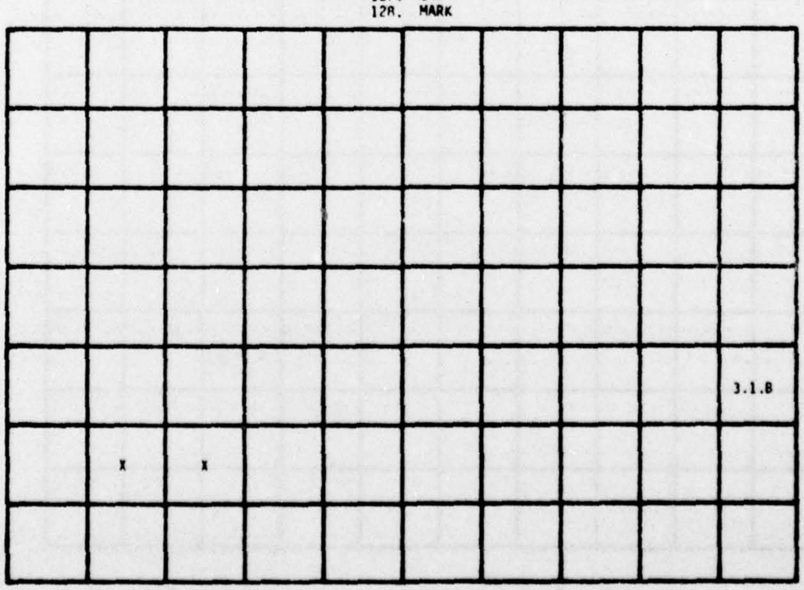
2. RECEPTION
   14. VISUAL DISPLAY, CHART
       M. GATE
          124. OFF THROUGH 20 kts



3. INTERFACES
1. FIRE CONTROL
A. ATF
125. OFF
126. ATF



3. INTERFACE
1. FIRE CONTROL
B. RANGE MARK
127. OFF
128. MARK



3. INTERFACE
   1. FIRE CONTROL
      C. BEARING MARK
         129. OFF
         130. MARK

3.1.C	X	X							

3. INTERFACE
   1. FIRE CONTROL
      D. ON TARGET
         131. OFF
         132. ON TARGET

	3.1.D								

3. INTERFACE
   1. FIRE CONTROL
      E. SEARCH
         133. OFF
         134. SEARCH

	X	3.1.E							

3. INTERFACE
   2. SHIP SYSTEMS
      A. OWN SHIP SPEED
         135. 0 TO 100 kts

X									X
						X			
			3.2.A						

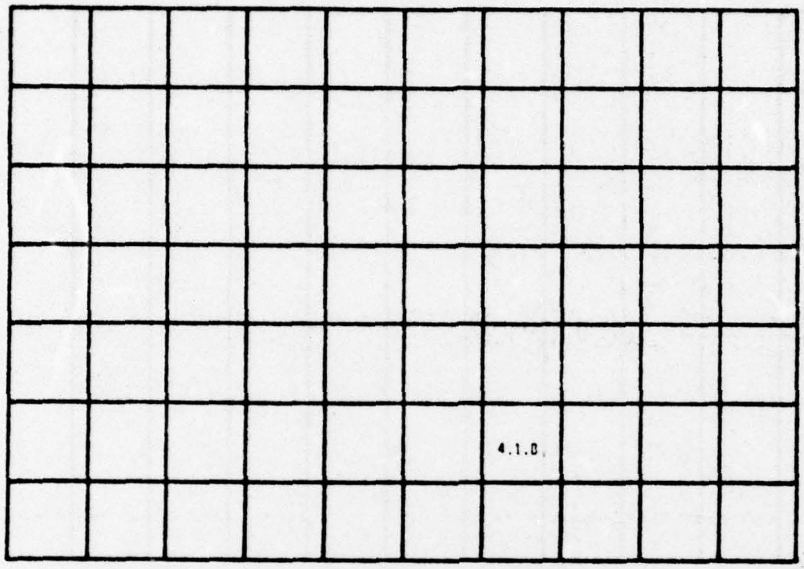
3. INTERFACE
   3. AUXILIARY
      A. TAPE RECORDER
         136. ON
         137. OFF

			3.3.A						

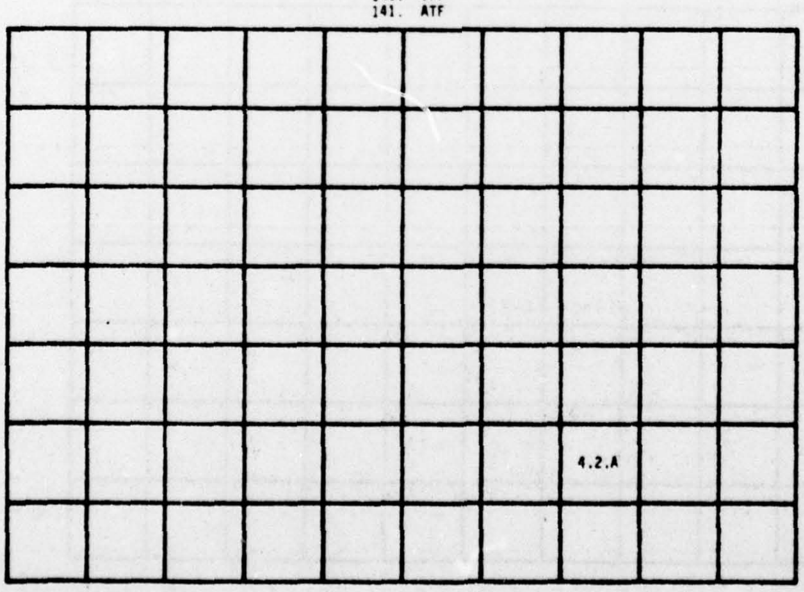
4. TRACKING
   1. MANUAL
      A. BEARING
         138. 0° TO 360°

					4.1.A				

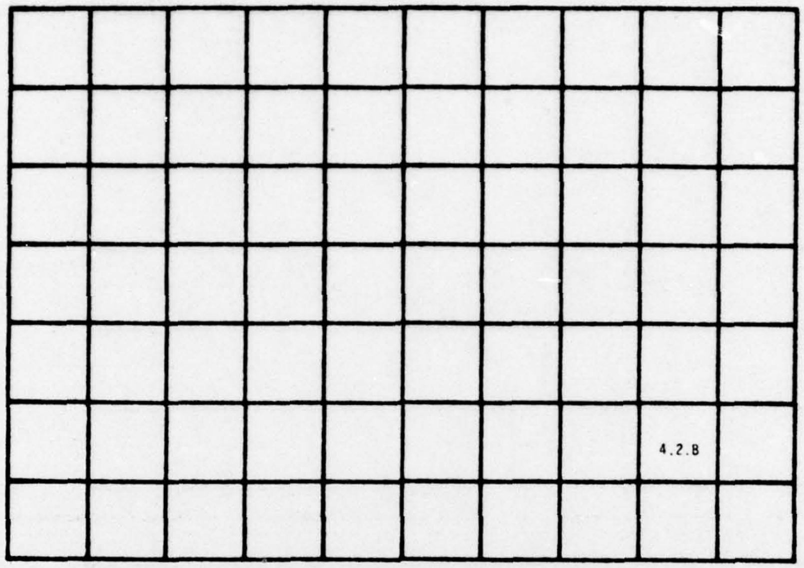
4. TRACKING
1. MANUAL
B. RANGE
139. 0 TO 100 kyds



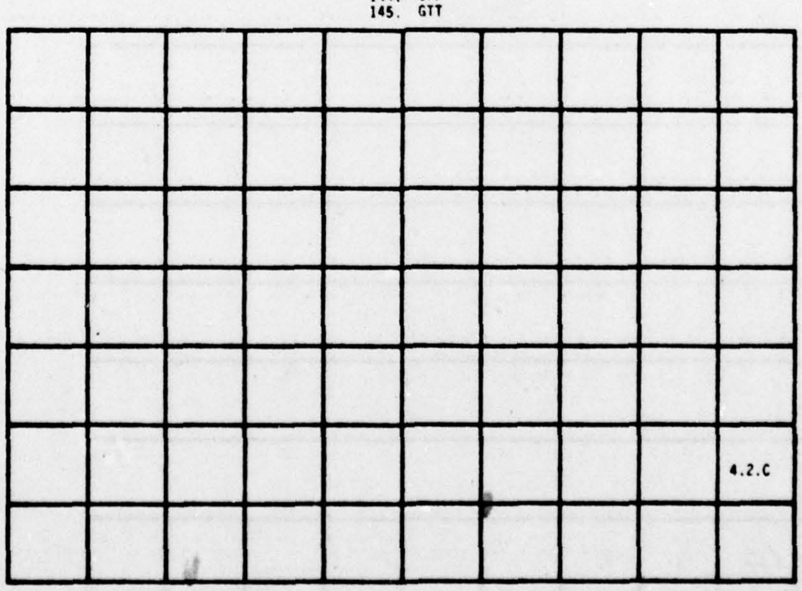
4. TRACKING
2. AIDED
A. ATF
140. OFF
141. ATF



4. TRACKING
   2. AIDED
      B. MTB
         142. OFF
         143. MTB



4. TRACKING
   2. AIDED
      C. GTT
         144. OFF
         145. GTT



4. TRACKING
  2. AIDED
    D. MCC
      146. OFF
      147. MCC

4.2.D									

4. TRACKING
  3. AUTOMATIC
    A. AUTOTRACKER SELECT
      148. OFF
      149. AUTO

	4.3.A	X	X						

4. TRACKING
   3. AUTOMATIC
      B. AUTOTRACKER NUMBER
         150. 1
         151. 2
         152. 3
         153. 4

	X	4.3.B	X						

4. TRACKING
   3. AUTOMATIC
      C. AUTOTRACKER ENGAGE
         154. ENGAGE
         155. DISENGAGE

	X	X	4.3.C						

5. PM/FL
1. MASTER TEST
156. OFF
157. TEST

				5.1	X	X			

5. PM/FL
2. SUBSYSTEM TEST
158. OFF
159. TEST

				X	5.2	X			

5. PM/FL
3. FAIL RESET
160. OFF
161. RESET

				X	X	5.3			

6. OTHER
1. SYSTEM POWER
162. OFF
163. ON

							6.1		

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